







CONCRETE MANUAL WORKBOOK

2015 IBC® AND ACI 318-14





Concrete Manual Workbook
Based on the 2015 IBC and ACI 318-14

Cover Design:	Duane Acoba
Project Editor:	Daniel Mutz
Project Head:	Sandra Hyde
Publications Manager:	Mary Lou Luif
Typesetting:	Sue Brockman

INTRODUCTION

This workbook is intended to provide practical learning assignments for independent study of the *Concrete Manual*. The independent study format provides a method for the student to complete the study program in an unlimited amount of time. Proceeding through the workbook, students can measure their level of knowledge by using the quizzes in each study session.

All study sessions contain specific learning objectives, a list of statements and questions summarizing the key points for study, and quizzes designed to assess the student's retention of technical knowledge. Therefore, before beginning the quizzes, students should thoroughly review the corresponding chapters of the *Concrete Manual* concerning the learning objectives and key points.

The quizzes are designed to encourage students to develop the habit of carefully reading the text for a clear understanding of the subject material. The questions are not intended to be tricky or misleading. The following three formats are used to vary the method of evaluation:

1. Multiple choice—Each statement is followed by a unique group of possible responses from which to choose.
2. True/False—Each statement is either true or false.
3. Completion—Each statement must be correctly completed by inserting the proper *Concrete Manual* text.

The workbook is structured so that every question is followed by the opportunity for students to record their responses and the corresponding text reference. The correct responses are indicated at the back of the workbook in the answer key so that students can assess their knowledge immediately.

ACKNOWLEDGMENTS

The International Code Council® (ICC®) would like to extend its appreciation to Donald M. Hunsicker for his preparation, under special contract to ICC, of the original text materials for this workbook. Mr. Hunsicker's development of this unique study aid provides an excellent resource to those individuals involved in the inspection of concrete.

Mr. Hunsicker was the Assistant Building Official with the City of Visalia, California. He has been active in the construction field for more than 25 years, with more than 15 years dedicated to the field of building inspection. Mr. Hunsicker holds degrees in Building Inspection Technology and Vocational Education. His writing credits include two other inspection-related workbooks published by ICC.

Since initial publication, the Concrete Manual Workbook has been updated by Gerald B. Neville, author of the Concrete Manual, to reflect later editions of the IBC and ACI 318.

TABLE OF CONTENTS

CHAPTER 1
FUNDAMENTALS OF CONCRETE

Objectives: To outline a brief history of cement and concrete, describe the hydration process, identify the characteristics of concrete, introduce the role of admixtures and the water-cement ratio, define “good, durable concrete” and the causes of distress or failure, and briefly discuss the five fundamentals of concrete.

Lesson Notes: Special attention should be given to the nine properties of good, durable concrete (they will be discussed in detail in subsequent chapters) and their relationship to the five fundamentals of concrete construction.

Key Points:

- From where does the term *pozzolan* originate?
- Who first developed Portland cement?
- What led to the large-scale production of cement?
- What is the first basic law of concrete technology?
- Describe the hydration process.
- For how long will the hydration process continue?
- What affects the rate of hydration?
- What is generated during hydration?
- Describe the difference between concrete, mortar and grout.
- What are the characteristics of fresh concrete?
- Define green concrete.
- Describe the water-cement ratio law.
- What factors contribute to concrete strength and durability?
- In what ways do admixtures modify concrete’s properties?
- Define the properties of “good, durable concrete.”
- Name three general reasons for the distress or failure of concrete.
- What facts should be considered when investigating a concrete failure?
- Name the five fundamentals of concrete construction.
- What is the most probable cause of distress in concrete?
- What does the term *workmanship* mean?
- How does maintenance affect a structure?

CHAPTER 1—QUIZZES

I Multiple Choice

1. Who developed the first Portland cement by burning limestone and clay at high temperatures?

   a. Romans
   b. Aspdin
   c. Eddystone
   d. Smeaton
   e. Greeks

   Response _____ Reference _____

2. Which one of the following is not one of the five fundamentals of durable concrete?

   a. material selection
   b. proper structure design
   c. reasonable cost
   d. site investigation
   e. workmanship

   Response _____ Reference _____

3. Fresh concrete is _____.

   a. green
   b. plastic
   c. newly placed
   d. self-supporting
   e. none of the above

   Response _____ Reference _____

4. Hydration produces _____.

   a. heat
   b. water
   c. drying
   d. cooling
   e. shrinkage

   Response _____ Reference _____

5. The first law of concrete to be researched and observed is the _____.

   a. hydration rate
   b. admixture reaction
   c. drying time/strength
   d. volume stability
   e. water-cement ratio

   Response _____ Reference _____

II True/False

6. Admixtures provide a means to achieve certain properties in fresh and hardened concrete.

   T_____ F_____ Reference _____

7. Good workmanship includes proper material selection.

   T_____ F_____ Reference _____

8. Deterioration of concrete is a maintenance concern only.

   T_____ F_____ Reference _____

9. Investigation of materials for the Hoover Dam resulted in development of low-heat of hydration cement.

   T_____ F_____ Reference _____

10. Portland cement is composed of lime and clay only.

    T_____ F_____ Reference _____

III Completion

11. Concrete with low strength and high moisture content, and that is only a few hours or days old, is referred to as _____ concrete.

    Reference _____

12. The property of concrete that resists attack by weather or substances is called _____.

    Reference _____

13. The forces of weather can be destructive to concrete through _____ and _____, which produce cracks, followed by the entrance of _____ into the cracks.

    Reference _____

14. Burnt_____was first developed in early Egypt.

    Reference _____

15. The _____ process of cement manufacture led to large scale production of cement worldwide.

    Reference _____

CHAPTER 2
THE FRESH CONCRETE

Objectives: To obtain an understanding of the significance of workability, how it is measured, the factors affecting it and the concurrent properties of segregation, bleeding, unit weight and air content.

Lesson Notes: *Consistency*, *cohesiveness* and *plasticity* are terms that are interrelated but describe different aspects of concrete's workability. Consistency is a measure of wetness or fluidity. Cohesiveness indicates whether concrete is harsh (low adhesion), sticky (high adhesion) or plastic (good adhesion and not easily segregated). Plasticity is the quality of fresh concrete that allows concrete to be molded or formed into a final configuration without segregation when properly handled.

Key Points:

- Define the terms *workability* and *plasticity*.
- What three terms are used to describe the workable aspects of concrete?
- Define consistency.
- What test measures consistency?
- What effect does temperature have on slump?
- What is meant by the term *cohesiveness*?
- What does a harsh concrete mix lack?
- Where might a harsh concrete mix be desirable?
- What is a common occurrence in a sticky concrete mix?
- Identify the factors that can affect workability.
- What is meant by the term *false set*?
- What is meant by the term *flash set*?
- How does aggregate affect workability?
- How might admixtures affect workability?
- Define the term *segregation*.
- In hardened concrete, what can be the result of segregation?
- Which type of concrete mixes tend to segregate?
- What is bleeding, and where does it occur most frequently?
- What can influence bleeding?
- Name the detrimental effects of too much bleeding.
- What is laitance?
- How would laitance affect a joint?
- Identify the causes of laitance.
- Define the terms *unit weight* and *yield of concrete*.
- Name the three ways to measure air content.
- How does air-entrainment affect concrete?

CHAPTER 2—QUIZZES

I Multiple Choice

1. The amount of air in nonair-entrained concrete is _____ percent.

   a. between one and two
   b. at least three
   c. as much as five
   d. a maximum of eight
   e. as high as ten

   Response _____ Reference _____

2. The element of workability that indicates whether fresh concrete is plastic, sticky or harsh is _____.

   a. cohesiveness
   b. consistency
   c. slump
   d. air content
   e. water content

   Response _____ Reference _____

3. Which one of the following is <u>not</u> a result of segregation?

   a. rock pockets
   b. laitance
   c. sand streaks
   d. bleeding
   e. scaling

   Response _____ Reference _____

4. A harsh and unworkable concrete mix can result from _____.

   a. finely ground cement
   b. fine aggregate
   c. adding pozzolans
   d. low cement content
   e. rounded or subrounded aggregates

   Response _____ Reference _____

5. A sticky concrete mix usually contains a high _____content.

   a. air
   b. aggregate
   c. cement or rock dust
   d. water and pozzolans
   e. pozzolans

   Response _____ Reference _____

II True/False

6. One of the most important properties of fresh concrete is workability.
   T_____ F_____ Reference _____

7. The type of structural element does not determine workability.
   T_____ F_____ Reference _____

8. Grading of coarse aggregate is more critical than grading of fine aggregate.
   T_____ F_____ Reference _____

9. Entrained air can cause segregation.
   T_____ F_____ Reference _____

10. A well-graded sand usually produces a low bleeding rate in concrete.
    T_____ F_____ Reference _____

III Completion

11. Air-entrainment can improve workability, lower _____ and reduce _____.
    Reference _____

12. The weight of 1 cubic foot of concrete is referred to as _____.
    Reference _____

13. Concrete that is fluid enough to flow into place without _____ or _____ will _____.
    Reference _____

14. Low-slump concrete mixes are commonly used for_____, _____ and _____.
    Reference _____

15. _____, especially in flat slabs, is accompanied by a slight settlement of solid particles.
    Reference _____

CHAPTER 3
THE STRENGTH OF CONCRETE

Objectives: To understand the importance of strength, the kinds of strength, how strength is measured and the various factors affecting strength.

Lesson Notes: Concrete is well known for its compressive strength. However, there are many factors that may affect this strength. By examining Table 3.3, you will gain an understanding into the causes and effects of some of these factors.

Key Points:

- At what age is concrete usually tested?
- What is the basis for acceptance or rejection of concrete?
- Other than strength, what properties of concrete can be significant?
- What is the standard size cylinder for testing compressive strength of concrete?
- Define the “modulus of rupture.”
- What test is a good indicator of tensile strength in concrete?
- What are the four basic methods by which concrete can be tested?
- What is a job-molded specimen?
- How does a Swiss hammer work?
- Describe how a Windsor probe tests concrete strength.
- What is one problem with strength tests?
- How does a high-water content affect concrete?
- How do aggregates affect strength?
- When are larger aggregates used?
- When are smaller aggregates used?
- Identify the three relationships between aggregates and concrete strength.
- What are considered to be the maximum amounts of rock dust or other fine materials acceptable in coarse and fine aggregate?
- How should organic matter be dealt with?
- How does aggregate moisture affect concrete batching?
- What types of chemicals are not acceptable in concrete mixing water?
- Is the volumetric measurement of ingredients good practice? Name the batching errors that may contribute to reduced concrete strength.
- What is considered the optimum temperature for placing concrete?
- Describe how freezing affects concrete strength.
- When is rapid strength development advantageous?
- Name the five methods to accelerate concrete strength.
- What type of cement is high-early, and how does it differ from other cements?
- When is calcium chloride not acceptable as an admixture in concrete?
- How might insulating forms contribute to curing?
- Where is high-temperature curing most frequently used?
- How would an overdose of a retarder admixture affect concrete strength?
- What occurs when concrete is placed and kept at near freezing?
- At what psi is concrete considered high strength?
- Where might high-strength concrete be used?

- At what age are specimens of 10,000 psi concrete usually tested?
- In what way can fire damage concrete?

CHAPTER 3—QUIZZES

I Multiple Choice

1. For valuation and acceptance of concrete, compressive strength tests are usually done when the specimens have been aged for_____days.

   a. 7
   b. 14
   c. 21
   d. 28
   e. 56

   Response _____ Reference _____

2. Other factors aside, the best range of temperature for placing concrete is between _____ ºF.

   a. 20 to 40
   b. 40 to 80
   c. 50 to 90
   d. 60 to 90
   e. 40 to 120

   Response _____ Reference _____

3. High-early-strength cement is made by increasing the amount of tricalcium silicate and _____.

   a. calcium chloride
   b. hydration
   c. air-entrainment
   d. high-temperature curing
   e. finer grinding of the cement

   Response _____ Reference _____

4. MSA stands for _____.

   a. modified-strength admixture
   b. maximum size aggregate
   c. modulus of shear axial
   d. minimum size aggregate

   Response _____ Reference _____

5. Mineral admixtures used to achieve strengths between 8,000 and 20,000 psi are _____.

   a. pozzolans and chert
   b. chert and ground manganese
   c. caliche and rock dust
   d. fly ash and silica fume
   e. calcium and aluminum silicate

   Response _____ Reference _____

6. A type of aggregate that should be avoided on account of its effects on strength is _____.

   a. crushed quartz
   b. any of glacial origin that contains organic matter
   c. any with a high specific gravity
   d. granite
   e. all of the above

   Response _____ Reference _____

7. Test specimens are valuable in that they give a measure of _____ and other properties of the concrete.

   a. specific gravity
   b. strength potential
   c. density
   d. durability resistance
   e. all of the above

   Response _____ Reference _____

8. A source of batching errors is _____.

   a. careless operation
   b. allowance for moisture variables in aggregates
   c. scales returning to zero between batches
   d. placing methods
   e. all of the above

   Response _____ Reference _____

9. Compressive strength of precast and prestressed concrete elements is typically specified to _____.

   a. below 2,000
   b. 2,500 to 3,500
   c. 3,000 to 4,000
   d. d.4,000 to 7,000

   Response _____ Reference _____

10. The strength of concrete most commonly measured is _____.
    a. compressive strength
    b. flexural strength
    c. tensile strength
    d. none of the above

    Response _____ Reference _____

11. As compared to the compressive strength of a 6-inch by 12-inch cylinder, the compressive strength of a 4-inch by 8-inch cylinder will generally be _____.
    a. significantly lower
    b. slightly lower
    c. about the same
    d. higher

    Response _____ Reference _____

12. The modulus of rupture of concrete is a measure of the _____.
    a. compressive strength
    b. tensile strength
    c. flexural strength
    d. shear strength

    Response _____ Reference _____

13. Tensile strength of concrete can be measured indirectly by a _____.
    a. compressive strength test
    b. flexural strength test
    c. split cylinder test
    d. direct tension test

    Response _____ Reference _____

14. Cores taken from near the top of a column will generally indicate _____ strength, compared with cores taken from near the bottom of the same column.
    a. higher
    b. lower
    c. about the same
    d. slightly higher

    Response _____ Reference _____

15. Commonly, the major causes of compressive strength test variation are _____.
    a. cement composition variations
    b. water-cement ratio variations
    c. cement temperature variations
    d. mixing speed variations

    Response _____ Reference _____

16. Concrete proportioned at the same water-cement ratio and made with well-graded aggregates having a maximum size of _____ will have the higher strength.
    a. $^{3}/_{8}$ inch
    b. $^{3}/_{4}$ inch
    c. $1^{1}/_{2}$ inches
    d. 3 inches

    Response _____ Reference _____

17. To gain strength rapidly during the first few days after placing, which one of the following can be used?
    a. high-early-strength cement
    b. an accelerating admixture
    c. curing at high temperature
    d. any of the above

    Response _____ Reference _____

18. Concrete will gain strength slowly if _____.
    a. it contains an overdose of a water-reducing admixture
    b. it contains an overdose of a retarder
    c. it contains an overdose of an accelerator
    d. the concrete and air temperature are 80ºF

    Response _____ Reference _____

19. Concrete heated to 800ºF for a long period of time and then cooled will have a permanent strength reduction of _____ percent.
    a. less than ten
    b. 10 to 40
    c. about 50
    d. 50 to 95

    Response _____ Reference _____

20. HSC stands for _____.

    a. high-strength cement
    b. high-strength concrete
    c. hydrogen-sulfate cement
    d. high-shrinkage cement

    Response _____ Reference _____

21. For structural concrete, the minimum specified compressive strength should not be less than _____ psi.

    a. 1500
    b. 2000
    c. 2500
    d. 3000

    Response _____ Reference _____

22. Specified compressive strength of concrete above about _____ psi is considered high-strength concrete.

    a. 4000
    b. 6000
    c. 8000
    d. 10,000

    Response _____ Reference _____

II True/False

23. There is no field test for direct determination of tension under axial loading.

    T_____ F_____ Reference _____

24. When concrete has to be cored to verify strength, damage to reinforcement is not of concern when the specified concrete strength is below 3,000 psi.

    T_____ F_____ Reference _____

25. A common accelerator admixture that is added to the batch in solution is calcium chloride.

    T_____ F_____ Reference _____

26. In general, load-bearing concrete members exposed to continuous heat in excess of 500ºF should be avoided.

    T_____ F_____ Reference _____

27. Watertightness is important in nearly all hydraulic structures.

    T_____ F_____ Reference _____

28. Irregularly shaped natural gravel or cube-shaped crushed rock with a rough and slightly porous surface will give the best bond with the cement paste.

    T_____ F_____ Reference _____

29. Concrete that will be continuously exposed to temperatures greater than 150ºF should be laboratory tested to determine if the expected temperature will be detrimental.

    T_____ F_____ Reference _____

30. Concrete made and cured at 50ºF will have lower strength at three days but higher strength at 28 days than concrete made and cured at 90ºF.

    T_____ F_____ Reference _____

31. Concrete strengths in the range of 6,000 to 10,000 psi at 56 days require new technology.

    T_____ F_____ Reference _____

III Completion

32. If concrete is placed and kept at a near-freezing temperature, the hydration process and strength gain will be _____.

    Reference _____

33. The _____ of _____ is a measure of flexural strength and can be determined by testing a beam specimen in flexure with a concentrated load at each of the _____ points. This beam is usually _____by _____ inches in cross section.

    Reference _____

34. Five basic methods to accelerate the early strength of concrete are _____ cement,_____ admixtures, _____ heat of hydration, _____ curing and rapid-setting _____.

    Reference _____

35. Aggregates with a specific gravity less than _____, or having an absorption rate exceeding _____ percent, are usually deficient in strength.

    Reference _____

36. Two nondestructive instruments for checking the strength of hardened concrete are a _____and a _____.

    Reference _____

CHAPTER 4
THE DURABILITY OF CONCRETE

Objectives: To understand the property of concrete known as *durability* and the agencies of destruction that affect durability. Also considered are the effects of a marine environment and of hydraulic structures on durability, as well as the typical problems associated with slabs on ground and prevention of deterioration.

Lesson Notes: When concrete is found to lack durability, the most common cause by far is inferior workmanship—specifically the use of too much mixing water. A high water content can lead to segregation, laitance, rock pockets, cracking, weak permeable layers and porous concrete. Emphasis should be placed on using only the amount of water specified for the mix.

Key Points:

- Define *durability*.
- To what properties of concrete is durability closely related?
- What are the six factors that affect durability?
- Name the three methods of measuring durability.
- Identify the four general categories of destructive agents.
- What are the necessary steps to protect concrete from destructive agents?
- What does petrographic examination reveal?
- What substances found in aggregates contaminate or weaken concrete?
- How might selection of cement type affect durability?
- How important is workmanship to durable concrete?
- In what way might mix proportions affect durability?
- List the substances that attack concrete.
- How does sea water deteriorate concrete?
- Identify a type of structure or exposure condition where each item listed in Table 4.1 might occur.
- How do acids affect concrete?
- What are some of the sources of acids?
- Why is calcium chloride an agent of deterioration?
- Which de-icing agents are best and worst for use on concrete?
- Explain how corrosion of steel reinforcement affects concrete.
- What are the effects of high temperatures on concrete's durability?
- What might be early indications of structural damage?
- What are the chief causes of structural damage?
- What are the factors that affect sulfate resistance?
- Name the types of aggregate that can be alkali-silica reactive.
- Describe the effect of alkali-silica reaction on concrete.
- What is the effect of freezing on fresh concrete?
- How does frost damage concrete?
- How can frost resistance of concrete be improved?
- How does good workmanship help concrete resist environmental attack?
- What are the main causes of slab-on-ground cracking?

- Define *scaling*, *spalling*, *subsidence*, *pumping* and *blowups* and the causes of each type of defect.
- Why is air-entrainment of concrete important?
- How is air-entrainment accomplished?
- What two points must be remembered about entrained air with respect to durability?

CHAPTER 4—QUIZZES

I Multiple Choice

1. Cavitation can be caused by _____.
   a. surface depressions
   b. surface projections
   c. sharp bends
   d. sudden changes in cross section
   e. all of the above

   Response _____ Reference _____

2. Concrete continually exposed to high temperature is affected primarily by _____.
   a. frequent spalling
   b. accelerated hardening
   c. a reduction of strength
   d. exhaust gases
   e. high- and low-temperature extremes

   Response _____ Reference _____

3. Concrete that expands and contracts abnormally may be caused by _____.
   a. unsound aggregates
   b. temperature changes
   c. reaction between aggregates and cement
   d. all of the above
   e. none of the above

   Response _____ Reference _____

4. Freezing of concrete in the plastic state will reduce durability, weather resistance and strength by as much as _____.
   a. one-fourth
   b. one-half
   c. three-fourths
   d. one-third
   e. two-thirds

   Response _____ Reference _____

5. Poor durability in concrete is rarely caused by _____.

   a. water
   b. cement
   c. aggregate
   d. workmanship
   e. mix proportions

   Response _____ Reference _____

6. Which one of the following is considered a reactive aggregate?

   a. feldspar
   b. quartz
   c. chert
   d. granite
   e. silica

   Response _____ Reference _____

7. Of the following de-icing agents, which one is not recommended?

   a. calcium chloride
   b. urea
   c. sodium chloride
   d. ammonium sulfate
   e. all of the above

   Response _____ Reference _____

II True/False

8. Concrete slabs placed in the late fall can be exposed to de-icing salts during the first winter of exposure, provided adequate curing is accomplished.

   T_____ F_____ Reference _____

9. Aluminum is attacked by caustic alkalies when exposed to moist concrete.

   T_____ F_____ Reference _____

10. When a slab is placed directly on a fine-grained, plastic, impervious soil, the presence of moisture may create a condition known as pumping.

    T_____ F_____ Reference _____

11. Normal weathering may cause a slight roughening of the surface or rounding of the edges but is not harmful to durable concrete.

    T_____ F_____ Reference _____

12. One strength of concrete is its ability to strongly resist acids.

    T_____ F_____ Reference _____

13. Entrained air does not improve the durability and other characteristics of concrete exposed to weather in severe climates.

    T_____ F_____ Reference _____

14. Streams may not be a good source of water for concrete if the water contains sulfates, tannic acid, organic materials or sugar.

    T_____ F_____ Reference _____

III Completion

15. _____ and _____ improve the appearance of a structure, and sharp arris, which is subject to spalling and chipping from moving objects, is avoided.

    Reference _____

16. The three types of waves that concrete structures should be designed for are _____, _____ and _____.

    Reference _____

17. Movement of paving slabs or blocks on the face of an embankment of reservoirs, sea walls or dams may be caused by _____ back pressure upon sudden _____ of the water level.

    Reference _____

18. When dealing with potential attack by chemical elements, either proper attention to produce _____ concrete or some sort of _____ should be provided to separate the concrete from the aggressive materials.

    Reference _____

19. The six factors that affect the durability of concrete are the _____ characteristics, _____ properties, _____ conditions, imposed _____, _____ practices and _____.

    Reference _____

20. _____salts are destructive to concrete because, in the alkaline environment of concrete, they release _____ gas and _____ ions that must be placed by dissolving calcium from the concrete, resulting in a leaching action similar to a(n) _____attack.

    Reference _____

CHAPTER 5
VOLUME CHANGES AND OTHER PROPERTIES

Objectives: To understand the effects and control of shrinkage, the role of reinforcement, thermal properties, watertightness and the cause of fatigue. Also discussed are the acoustical, electrical and elastic properties of concrete.

Lesson Notes: Expansion and contraction are important to the dimensional stability of the structure, and creep or plastic flow may cause an undesirable change in the stresses distributed through the structure. Water is once again at the heart of most problems. As you are studying this chapter, note how factors such as shrinkage, bleeding and watertightness are directly or indirectly affected by the amount of water in the mix.

Key Points:

- At what point is concrete subject to shrinkage?
- Why does concrete shrink?
- Name the factors that affect shrinkage.
- Besides water loss, why else might concrete shrink?
- What is the most important factor in minimizing shrinkage?
- How would a water-reducing admixture affect shrinkage?
- What percent of sand should pass a 100-mesh screen? A 50-mesh screen?
- What is the recommended slump for slabs?
- How is water lost from concrete?
- Define *plastic* shrinkage.
- What happens when there is a rapid loss of bleed water?
- Describe the effects of low humidity and wind on plastic shrinkage.
- Can a minor change in weather have a great effect on evaporation? Explain using Figure 5-3.
- When is bleeding detrimental to concrete, and what are the negative effects?
- What is drying shrinkage?
- What has the greatest effect on drying shrinkage?
- How much drying shrinkage will occur with 300 pounds of water per cubic yard?
- What is the range of drying shrinkage?
- Name the factors that can help limit drying shrinkage.
- How does the volume of concrete change when it gets warm or cool?
- What can happen when concrete is restrained from movement?
- Do volume changes caused by temperature affect concrete differently than those caused by moisture?
- How does reinforcement affect shrinkage?
- Describe the chemical methods of drying shrinkage control.
- Why should aluminum powder not be used to control shrinkage.
- How could a volume change be measured?
- What is meant by the term *coefficient of expansion*?
- What is conductivity?
- Does concrete have a fairly high “*k*” value?
- Name the three things that influence concrete’s conductivity.

- What is the Btu range for concrete?
- Identify the ways in which the "*k*" value of concrete is important.
- Define *specific heat* and *diffusivity*.
- Define *modulus of elasticity*.
- What is the stress-strain curve of hardened concrete?
- What might the elastic modulus tell us about concrete?
- How is the modulus of elasticity related to compressive strength?
- Define *creep*.
- What is the difference between creep and plastic flow?
- What is the rate of creep in relationship to time?
- Name the two components of creep.
- Define *permeability*.
- On what does the permeability of concrete depend?
- How is porosity affected by the water-cement ratio?
- Name the three factors that are most important to the watertightness of concrete.
- List the six principles and precautions for obtaining watertightness of concrete.
- Describe two methods for minimizing moisture problems on enclosed slabs.
- Summarize the best way to obtain impermeable concrete.
- Is concrete an insulator or conductor?
- Define *yield*.
- Identify the factors that can contribute to loss of yield.

CHAPTER 5—QUIZZES

I Multiple Choice

1. Lack of watertightness in concrete can almost always be traced to _____ .
   a. porous aggregates
   b. improper cement/aggregate proportions
   c. poor construction practices
   d. creep
   e. waterproofing admixtures

   Response _____ Reference _____

2. When used as an accelerator _____ causes an increase in shrinkage.
   a. pozzolan
   b. fly ash
   c. calcium chloride
   d. tricalcium aluminate
   e. sandstone

   Response _____ Reference _____

3. Which one of the following does not affect shrinkage in concrete?
   a. water-cement ratio
   b. aggregate grading
   c. weather conditions
   d. cement content
   e. quality of curing

   Response _____ Reference _____

4. Moisture problems associated with slabs-on-ground can be minimized by _____.
   a. installing a vapor barrier
   b. laying a 1-inch sand base sub-base
   c. using an admixture that helps to retain water
   d. air-entrainment
   e. using less water in the mix design

   Response _____ Reference _____

5. The rate at which a material conducts heat through a 1-inch thickness per unit of area is known as_____.

   a. Btu
   b. diffusivity
   c. "*k*" value
   d. modulus
   e. coefficient of expansion

   Response _____ Reference _____

6. The property of concrete that indicates its ability to change in volume with changes in temperature is known as its _____.

   a. conductivity
   b. coefficient of expansion
   c. diffusivity
   d. modulus of elasticity
   e. dynamic creep

   Response _____ Reference _____

7. Which one of the following factors will not help limit shrinkage in concrete?

   a. smallest size aggregate possible
   b. proper consolidation
   c. good workmanship
   d. proper curing
   e. intelligent use of admixtures

   Response _____ Reference _____

II True/False

8. Yield is defined as the volume of concrete per cubic yard.

   T_____ F_____ Reference _____

9. A critical factor for minimizing shrinkage in concrete is the total water per cubic yard.

   T_____ F_____ Reference _____

10. Reinforcing steel is rarely used to help control shrinkage.

    T_____ F_____ Reference _____

11. Concrete does not start losing water for about 15 to 20 minutes after placement unless Type III cement is used or concrete is in contact with earth.

    T_____ F_____ Reference _____

12. Creep is a time-dependent deformation of concrete under varying loads.

    T_____ F_____ Reference _____

13. Entrained air decreases drying shrinkage, but because air entrainment requires the use of more water, the effect on shrinkage is negligible.

    T_____ F_____ Reference _____

14. A small amount of bleeding is not detrimental to concrete and, in fact, can result in a slightly stronger paste.

    T_____ F_____ Reference _____

III Completion

15. _____humidity in the air and _____ are the principle causes of high evaporation. However, _____ temperature can also be significant.

    Reference _____

16. Aluminum is not an acceptable method to control shrinkage and should not be used in normal construction because of _____ and the possible _____ of strength.

    Reference _____

17. Concrete is a _____ conductor of sound because it is a _____ material.

    Reference _____

18. When water loss is fairly slow, the concrete can adjust to the reduction in _____, whereas a rapid loss of _____ water from the surface of a slab will introduce a _____ stress in the surface layer.

    Reference _____

19. The modulus of elasticity is the _____ of a substance and is known by the letter _____.

    Reference _____

20. Volume change is the_____ and _____ of concrete that results from temperature changes or _____ and drying. These changes are _____.

    Reference _____

CHAPTER 6
CRACKS AND BLEMISHES

Objectives: To become familiar with the causes and prevention of cracks and blemishes and to obtain an understanding of how repairs to concrete are made.

Lesson Notes: The properties of concrete are all interrelated. When one symptom appears, we can be sure that other properties will be affected. Cracks and blemishes seen on the surface usually indicate a problem below the surface that cannot be seen.

Key Points:

- Cracking:
- Cracks and blemishes can result from a deficiency in which properties of concrete?
- Can cracking be prevented?
- Why does concrete crack?
- What are the main causes of cracking?
- What are plastic shrinkage cracks?
- How do plastic shrinkage cracks differ from cracks in hardened concrete?
- Where do plastic shrinkage cracks usually occur?
- Describe how weather can influence plastic shrinkage cracking?
- How can plastic shrinkage cracking be minimized?
- How does evaporation affect plastic shrinkage cracking?
- Identify the ways that plastic shrinkage cracking can occur prior to hardening.
- Describe how settlement or movement in the concrete, forms, subgrade and soil can contribute to cracking.
- What is the cause of drying shrinkage cracks?
- What role does restraining of concrete play in drying shrinkage cracking?
- Name the other important factors that contribute to drying shrinkage cracks.
- How does tensile strength of concrete relate to cracking?
- What is a structural crack?
- What are the job conditions that can cause structural cracks?
- What is the result of reactive aggregates in hardened concrete?
- Describe how rusting of reinforcing steel can cause concrete cracking.
- Define *thermal shock*.
- How does thermal shock occur and what is the result?
- Where do weathering cracks occur most frequently?
- At what point do freezing and thawing cycles no longer affect concrete?
- Define *crazing*.
- When is crazing most noticeable?
- Identify the three general causes of crazing.

Blemishes:

- What is meant by the term *dusting*?
- How can a dusting surface be made hard?
- Why is tannin harmful to concrete?
- In what way might heaters have a negative effect on plastic concrete?
- What is the most frequent cause of dusting?

- How does a lack of curing create dusting?
- What causes bugholes?
- Do bugholes create structurally unsound concrete?
- What are the ways to eliminate or reduce bugholes?
- Name the causes of bubbles and blisters.
- What are rock pockets, and how do they form?
- What are the principle causes of rock pockets?
- How can you prevent concrete from sticking to forms?
- How might a blemish occur at a horizontal construction joint?
- List the types of materials that may stain or discolor concrete.
- When using white cement, what materials should be avoided?
- Why should dry cement NOT be used to absorb water?
- Name the possible causes for irregular dark areas in slabs.
- What procedures can be used to minimize dark spots in slabs?
- Define *efflorescence*.
- How is efflorescence formed?
- How can efflorescence be reduced?
- Describe how efflorescence is removed.
- What is laitance?
- What are the causes of laitance?
- Define *scaling*.
- What are the causes of scaling?
- Identity the best preventative measures for scaling when concrete is exposed to freezing and thawing.
- Define *spalling*.
- List the causes of spalling.
- How is spalling avoided?
- What is popout and what are the causes?
- What is usually present when popouts occur?
- How are popouts prevented?
- Can popouts be repaired?

Repair of Defects:

- Describe the differences between structural and cosmetic repairs.
- What are the methods used to repair concrete?
- Do all patches require wetting of the old concrete?
- When is dry pack used?
- Of what materials and proportions does dry pack consist?
- Describe how dry pack is installed.
- What is the procedure for repairing with an overlay?
- What types of materials can be used to fill cracks?
- How are large cracks filled?
- How can mortar bond be improved?
- Describe the epoxy process for filling cracks in both vertical and horizontal elements.
- How are bonding agents applied?
- Describe the process of joining concrete with adhesives.

CHAPTER 6—QUIZZES

I Multiple Choice

1. Which one of the following is not a crack that occurs while concrete is still plastic?

   a. green
   b. plastic shrinkage
   c. pre-set
   d. drying shrinkage
   e. none of the above

   Response _____ Reference _____

2. Sudden changes in temperature that can stress concrete and cause cracks are called _____.

   a. reactive thermoset
   b. thermal shock
   c. frost action
   d. freezing and thawing cycles
   e. drying shrinkage

   Response _____ Reference _____

3. Joint dowels in slabs on ground should be _____.

   a. coated with a lubricant
   b. perpendicular to the subgrade
   c. secured against slippage
   d. placed off center
   e. all of the above

   Response _____ Reference _____

4. A deposit of crystalline salts on hardened concrete brought by water and deposited on the concrete surface through evaporation is called _____.

   a. laitance
   b. spalling
   c. scaling
   d. efflorescence
   e. drying scale

   Response _____ Reference _____

5. The minimum thickness of a bonded overlay for slab repairs should not be less than _____.

   a. 1 inch
   b. 2 inches
   c. 3 inches
   d. $1^1/_2$ inches
   e. $2^1/_2$ inches

   Response _____ Reference _____

6. Unvented heaters used for heating an enclosure during cold weather will cause a reaction when _____ come(s) in contact with the surface of green concrete.

   a. hydrogen ions
   b. ferruginous concretions
   c. chloride salts
   d. silica
   e. carbon dioxide

   Response _____ Reference _____

7. The breaking away of a small piece of concrete in the shape of a cone on the surface of a concrete slab is called a _____.

   a. scale
   b. spall
   c. popout
   d. pit
   e. void

   Response _____ Reference _____

8. _____ cracks are caused primarily because of loss of water from new concrete after it has hardened.

   a. plastic shrinkage
   b. spalling
   c. drying shrinkage
   d. hydration
   e. contraction

   Response _____ Reference _____

II True/False

9. Concrete in structures consisting of a large amount of concrete in huge blocks or masses is called *mass concrete*.

   T_____ F_____ Reference _____

10. Contraction joints should be spaced not more than about 30 feet apart.

    T_____ F_____ Reference _____

11. When concrete is first placed in forms, it contains large amounts of entrapped air that cause voids called air pockets, which can be removed if proper vibration is applied.

    T_____ F_____ Reference _____

12. Discoloration of concrete can be caused by certain plywoods, hardboards, form oils and iron pyrites.

    T_____ F_____ Reference _____

13. The dry pack method of repairing concrete requires special knowledge and can only be applied by certified installers.

    T_____ F_____ Reference _____

14. Concrete surfaces to be bonded by adhesives must be sound and thoroughly wetted prior to application.

    T_____ F_____ Reference _____

15. Preparation for repair of concrete begins with removal of unsound and disintegrated concrete.

    T_____ F_____ Reference _____

16. Concrete cracks are due to compressive forces that pull the concrete apart before tensile strength is adequate.

    T_____ F_____ Reference _____

III Completion

17. Settlement of concrete may be obstructed by _____, _____ in the concrete or large _____, causing _____ in the concrete over these obstructions.

    Reference _____

18. Diagonal cracks at corners of door and window _____ can be controlled by the use of sufficient _____.

    Reference _____

19. Isolation joints should be provided whenever concrete abuts _____ concrete in _____, _____ or footings.

    Reference _____

20. The first step in repairing concrete is to _____ the damage, including determination of the _____ and the _____.

    Reference _____

21. Cracking of precast concrete can be minimized if units are_____, avoiding variable _____ and providing adequate _____.
    Reference _____

22. One of the worst blemishes in a horizontal concrete surface is a sloughing away or _____of the surface in thin flakes called _____.
    Reference _____

23. Large cracks can be filled with epoxy mortar consisting of epoxy _____ mixed with _____ in the proportion of _____part_____ to _____ parts _____by volume.
    Reference _____

24. Often appearing as circular or oval depressions on concrete surfaces, _____ is a deeper surface defect than scaling, and can be _____ or more in depth and _____or more in diameter.
    Reference _____

CHAPTER 7
PORTLAND CEMENT

Objectives: To obtain a basic understanding of the way cement is manufactured; its composition, properties and characteristics; and the methods of its transportation and storage.

Lesson Notes: For a better understanding of how cement is made, study Figure 7-3 as you read Section 7.2.

Key Points:

- What is meant when it is said that cement is hydraulic in nature?
- Of what raw materials is cement made?
- What is the process of making cement called?
- Describe the first phase of cement manufacture.
- After the blended material is stored, what are the two possible processes prior to its being sent to the kiln?
- Describe the burning and finishing process.
- What are clinkers?
- What materials are added during finish grinding?
- Describe each of the five main types of cement, including the characteristics and uses of each.
- What are the three types of air-entrained cements?
- What is blended cement?
- What is added to cement to make each of the following types? IS, IS-A, P, IP, S, I(SM) and I(PM)
- What is masonry cement?
- How does white cement differ from gray cement?
- Name some uses of white cement.
- What is added to cement to make plastic cement, and what are its most common uses?
- How does expansive cement differ from other cements?
- Where is expansive cement used most effectively?
- Calcium aluminate cement is used for what applications?
- Can aluminous cement be used for structural concrete?
- How is magnesite made, and where is it used?
- Where is rapid-setting cement used most frequently?
- What are the two basic types of hauling equipment used to transport cement?
- What is warehouse set?
- How is bulk cement usually stored?
- What are two concerns when storing cement?
- Why is it important for all equipment used in handling cement to be weathertight?

CHAPTER 7—QUIZZES

I Multiple Choice

1. The specific gravity of Portland cement is about _____.

   a. 2.75
   b. 2.92
   c. 3.15
   d. 3.25
   e. 3.40

   Response _____ Reference _____

2. Type IV cement is a special cement that generates less heat during hydration and is used only in mass concrete such as _____.

   a. high-rise buildings
   b. large parking structures
   c. large dams
   d. tilt-up buildings
   e. water treatment plants

   Response _____ Reference _____

3. The process of making cement is called _____.

   a. hydration
   b. hydraulic kiln refining
   c. clinker
   d. pyroprocessing
   e. heat stearation

   Response _____ Reference _____

4. Type _____ cement is used when high early strengths are desired.

   a. I
   b. II
   c. III
   d. IV
   e. V

   Response _____ Reference _____

5. Which one of the following is not a property or characteristic of cement?

   a. fineness
   b. setting time
   c. color
   d. workability
   e. soundness

   Response _____ Reference _____

6. The two basic classes of fly ash are _____.
   a. A and B
   b. B and D
   c. C and F
   d. D and G
   e. A and D

   Response _____ Reference _____

7. Pozzolans are used to improve _____and reduce _____.
   a. plasticity, air-entrainment
   b. durability, water volume
   c. workability, bleeding
   d. hydration, heat loss
   e. drying shrinkage, cohesiveness

   Response _____ Reference _____

II True/False

8. In the manufacture of Portland cement, the divergence of the dry and wet process ends when the kiln feed is put into storage.

   T_____ F_____ Reference _____

9. Cement sacks can be stacked directly on a warehouse floor, provided there is no moisture coming through the floor.

   T_____ F_____ Reference _____

10. Shipments of cement to the customer are made either in bulk or in 94-pound bags, the latter of which equal about $^{1}/_{2}$ cubic foot.

    T_____ F_____ Reference _____

11. Color is an indication of cement quality.

    T_____ F_____ Reference _____

12. One problem with storing cement in silos is a tendency for a hollow core to develop in the center when the cement is withdrawn from the bottom.

    T_____ F_____ Reference _____

13. In the dry process of making cement, grinding and blending operations are done with the materials mixed with water in a slurry form.

    T_____ F_____ Reference _____

14. Air-entrained concrete is commonly made by using air-entraining Portland cements.

    T_____ F_____ Reference _____

15. Silica fume is a material that is used as a pozzolanic admixture.
    T_____ F_____ Reference _____

16. One source of pozzolans is calcined or burnt shales and slates, heated in a stationary kiln and crushed and ground after cooling.
    T_____ F_____ Reference _____

III Completion

17. Type V cement is a special _____ cement. It is used where concrete is exposed to _____ or _____water that is high in _____ content.
    Reference _____

18. Greater cement fineness increases the rate at which cement _____ and _____ strength development.
    Reference _____

19. Portland blast-furnace slag cement can be either Type _____ or _____ ; slag cement is Type _____ ; and Portland-pozzolan cement can be either Type _____ or _____.
    Reference _____

20. During finish grinding of cement, a small amount of _____ is interground with the cement to control _____ .
    Reference _____

21. White Portland cement contains no _____ and meets the requirements for Type _____ Portland cement. It is pure white in color and allows for a great amount of variety in _____or _____ concrete.
    Reference _____

22. When working with fresh concrete, care should be taken to avoid _____ or _____.
    Reference _____

23. Some of the most common natural pozzolans are _____, _____, _____ and _____.
    Reference _____

24. Dependent on other material costs, fly ash is more economical, as well as more resistant to _____and _____ reaction, and has a _____ of hydration.
    Reference _____

CHAPTER 8
AGGREGATES

Objectives: To identify the different types and sources of rock used as aggregate, as well as the characteristics, processing, stockpiling and testing of aggregate materials. The special kinds of aggregates will be studied in a brief overview.

Lesson Notes: Aggregates are normally inert materials and do not react with concrete; however, there are some aggregates to which this generally does not apply. Throughout this chapter, note the types of aggregates that may react with the concrete.

Key Points:

- How much of the volume of concrete is occupied by aggregates?
- What class of rock makes the most consistently good aggregate?
- Describe the differences between the three rock classes.
- How is aggregate quality determined?
- List the seven properties that affect aggregate quality.
- How are aggregate soundness and stability determined?
- How is cleanness determined?
- Name the materials that can negatively affect aggregate quality.
- How is aggregate hardness determined?
- By what name is a common grading test known?
- How is the fineness modulus of sand determined?
- What is the most desirable grading curve?
- Review Section 3.11 on the maximum size aggregate (MSA). What effect does the MSA have on concrete?
- What is the main influence on aggregate shape?
- Describe the differences between aggregate shape and texture.
- Which aggregate texture is most desirable?
- Why is a petrographic analysis of aggregate important?
- Define *specific gravity*.
- How can the specific gravity of aggregate affect concrete?
- Describe how absorption affects aggregate quality.
- Why must the absorption of an aggregate be known?
- Identify the four possible aggregate moisture content conditions.
- Why is knowing the moisture content necessary?
- Define *unit weight*.
- What is void content, and why is it important?
- Why is it rare to find aggregate that is dug out of the ground ready to be used in concrete?
- How is poor grading remedied?
- What should be removed from coarse aggregate before primary crushing?
- What equipment is used for initial, intermediate and final crushing?
- Describe the purposes of a revolving scrubber, a log washer and a screw washer.
- Define *fine aggregate*.
- How is sand grading accomplished?

- Review the effect of sand grading on concrete.
- How can the defects of pit-run sand be corrected?
- What is aggregate beneficiation?
- How can segregation be minimized when stockpiling coarse aggregate?
- How does sand differ from coarse aggregate in regard to segregation?
- How is moisture in sand usually measured?
- Why is sampling from a stockpile difficult?
- How should a sample be obtained from a conveyor belt?
- When is the quartering method used for aggregate sampling?
- Describe the quartering method of aggregate sampling.
- What is slag?
- How is slag processed?
- How does slag compare to natural aggregate?

CHAPTER 8—QUIZZES

I Multiple Choice

1. The greater the size range within a gravel stockpile, the greater the danger of harmful _____ .

   a. beneficiation
   b. hydration
   c. segregation
   d. scrubbing
   e. rounding

   Response _____ Reference _____

2. Which one of the following is not a characteristic of an aggregate?

   a. cleanness
   b. durability
   c. texture
   d. reactivity
   e. absorption

   Response _____ Reference _____

3. When taking a sample of sand for testing, the sample size should be _____ pounds.

   a. 10
   b. 20
   c. 30
   d. 40
   e. 50

   Response _____ Reference _____

4. The limit of deleterious substances in aggregate should not be more than _____ percent by weight, depending on the substance.

   a. one to two
   b. two to three
   c. three to four
   d. four to five
   e. five to eight

   Response _____ Reference _____

5. The particle shape of an aggregate that will tend to make a harsh concrete mix is _____.

   a. angular
   b. rounded
   c. subrounded
   d. crushed
   e. circular

   Response _____ Reference _____

6. Unsatisfactory grading of aggregates can be corrected by _____.

   a. breakage
   b. segregating
   c. crushing and screening
   d. scalping
   e. spalling

   Response _____ Reference _____

7. Coarse aggregate samples should be reduced in size by using _____.

   a. a sample splitter
   b. the quartering method
   c. dry selection
   d. wet selection
   e. beneficiation

   Response _____ Reference _____

8. Sand or fine aggregate for concrete consists of material that will pass a No. _____ screen.

   a. 4
   b. 5
   c. 6
   d. 7
   e. 8

   Response _____ Reference _____

II True/False

9. A useful number when studying aggregate gradation is the fineness modulus.

   T_____ F_____ Reference _____

10. Aggregates in concrete are frequently called *filler material* because they occupy between 60 and 80 percent of concrete volume.

    T_____ F_____ Reference _____

11. The quality of rock in a quarry is fairly consistent, especially for limestone and granite rock.

    T_____ F_____ Reference _____

12. Aggregates for structural concrete can be either natural or artificial and may weigh as little as 75 pounds per cubic foot.

    T_____ F_____ Reference _____

13. Natural aggregates used in concrete come either from solid bedrock or deposits of sand and gravel.

    T_____ F_____ Reference _____

14. Sand and gravel are most frequently dug out of the ground and used directly in concrete.

    T_____ F_____ Reference _____

15. Segregation of materials in a gravel stockpile can be minimized by having a greater size range.

    T_____ F_____ Reference _____

16. The average specific gravity of sand or gravel is 2.65, which means it is 2.65 times as heavy as water.

    T_____ F_____ Reference _____

17. When different size aggregates are combined, the spaces between the aggregate particles decrease.

    T_____ F_____ Reference _____

III Completion

18. Aggregate samples are taken from a conveyor belt by stopping the belt, taking at least _____ portions and combining them to form a sample. _____ templates shaped to fit across the belt must be inserted and all material between the templates, including _____ and_____, removed.

    Reference _____

19. Of the several varieties of slag, slag that comes from a _____ is the most suitable for use in concrete.

    Reference _____

20. There are_____ basic classes of rock. They are _____, _____ and _____.

    Reference _____

21. Hard, dense stone such as granite may have an absorption rate of only _____ percent, whereas the absorption rate of a shale or porous chert is as high as _____ percent. The absorption rate for sand should not exceed _____ percent.

    Reference _____

22. The limits for deleterious substances in fine aggregate for concrete is about _____ percent for clay lumps and between _____ and _____ percent for coal and lignite.

    Reference _____

23. There are four commonly used methods of beneficiation. They are _____ separation, _____ , _____ and _____

    Reference _____

24. Aggregate scrubbing is required when adherent coatings of _____ and _____ cannot be removed from aggregate by washing and screening. The three methods of scrubbing are (1) use of a _____ scrubber, (2) a _____ or (3) a _____.

    Reference _____

25. To avoid segregation of materials when stockpiling aggregate, the following precautions should be observed. Handle as _____ times as possible, avoid _____, _____ shaped piles, stockpile in _____, handle in _____ graded sizes and remove from the stockpile in _____ slices.

    Reference _____

26. A _____ texture is desirable in aggregates, as it provides better bond with the _____ , making concrete of better strength compared with _____ surfaced aggregates.

    Reference _____

CHAPTER 9
WATER AND ADMIXTURES

Objectives: To understand the effects of water, various admixtures, pozzolans and fly ash on plastic, fresh and hardened concrete.

Lesson Notes: Water is absolutely necessary. It lubricates and makes concrete plastic and workable, and provides the catalyst for the reaction with the cement. However, when the amount of water exceeds the specified limits, the benefits of water become liabilities. As the water-cement ratio rises, strength, durability, workability and other properties of concrete diminish.

Admixtures, when used, must conform to American Society for Testing and Materials (ASTM) standards and the manufacturer's specifications. To avoid defects in the concrete, the effects of an admixture on the other concrete materials and the site conditions must be known before introduction into a mix.

Key Points:

- Name two things that water does to cement.
- Why is increasing the water-cement ratio not good for concrete?
- Up to how much dirt or silt is acceptable for water used for concrete?
- Define *ppm* and *TDS*.
- Without testing, how can contaminated water be identified?
- Describe the possible effects of sea water if used in concrete.
- What effect does sea water have on steel reinforcement?
- What are the three general classes of admixtures and the seven types of chemical admixtures?
- Name some concerns when choosing an admixture.
- Why use admixtures?
- How should an admixture be tested?
- What three concerns should be kept in mind when selecting an admixture?
- How are liquid admixtures measured?
- When using an admixture, what capabilities should the dispensing system have?
- Why should an admixture in a dry or powdered state never be introduced into concrete?
- Name some methods for dispensing admixtures.
- Should admixtures be intermixed prior to mixing?
- Is the time frame for adding admixtures ever critical?
- What does an accelerator do to concrete?
- What are the benefits of an accelerator?
- How and in what manner should calcium chloride be added to concrete?
- Identify the effects of calcium chloride on fresh and hardened concrete.
- How does a water reducer affect concrete?
- What are the advantages of water reducers?
- How does a retarder affect concrete?
- How is a retarder evaluated?
- How might temperature affect a retarder?

- Identify the benefits of air-entrainment.
- Describe how the disadvantages of air-entrainment can be offset.
- When is the best time to add air-entraining agents to the concrete mix?
- What factors can change the amount of entrained air?
- Name the most frequent causes of water leakage through concrete.
- Identify the types of bonding agents most frequently used for concrete.
- What type(s) of compounds can be used as antifreeze agents?
- What are the best workability agents?
- How can shrinkage be chemically controlled?
- Name the four kinds of finely divided mineral admixtures.
- When can a superplasticizer be used in concrete?
- How does a superplasticizer react with concrete?
- What benefits can be obtained from using a superplasticizer?
- Define *pozzolan*.
- Name the three general classes of pozzolans.
- What are the two classes of fly ash, and how are they produced?
- What are the benefits of including fly ash in a concrete mix?

CHAPTER 9—QUIZZES

I Multiple Choice

1. A retarder is an admixture that _____ the chemical process of hydration.

   a. increases
   b. slows
   c. accelerates
   d. stops
   e. none of the above

   Response _____ Reference _____

2. The reason for using an admixture is to _____ of concrete so that it will be more suitable for a particular usage.

   a. change the slump
   b. reduce segregation
   c. enhance the chemical properties
   d. reduce the cracking
   e. modify the properties

   Response _____ Reference _____

3. A superplasticizer admixture is used in concrete to _____.

   a. reduce the amount of water
   b. reduce cement content without reducing strength
   c. produce a flowing, self-leveling concrete
   d. all of the above

   Response _____ Reference _____

4. The total air content for concrete exposed to freezing and thawing conditions in a moderate exposure when the MSA is $^{3}/_{4}$ inch should be _____ percent.

   a. six
   b. five
   c. four
   d. four and one-half
   e. three

   Response _____ Reference _____

5. Which one of the following is an acceptable source for concrete mixing water?
   a. a private well
   b. the sea water
   c. a stagnant pool
   d. a brackish body of water
   e. a swamp

   Response _____ Reference _____

II True/False

6. An accelerator speeds up setting time and increases the rate of early strength development.

   T_____ F_____ Reference _____

7. Entrained air in concrete increases bleeding and reduces segregation tendencies.

   T_____ F_____ Reference _____

8. There is no material that can be put into a batch of fresh concrete to lower the freezing point without damaging the concrete.

   T_____ F_____ Reference _____

9. In general, sugar in mixing water is not objectionable.

   T_____ F_____ Reference _____

10. Expansion producing admixtures compensate for drying shrinkage of concrete and are usually incorporated in expansive cement.

    T_____ F_____ Reference _____

11. Admixtures used to make high-slump flowing concrete are often called *superplasticizers*.

    T_____ F_____ Reference _____

III Completion

12. When using more than one admixture, they should not be_____ prior to introduction into the mixer unless the _____ state that it is permissible.

    Reference _____

13. Bonding agents can be applied to the _____ to be bonded or used as admixtures, and can be made from _____ or _____ rubber or _____.

    Reference _____

14. Stearates, used as a permeability-reducing admixture, reduce _____ and retard _____ but are of little or no value if the water is under pressure.

    Reference _____

15. Coloring admixtures should be _____ in sunlight, _____ in the presence of alkalies, and have no adverse effects on _____ or _____ development.

    Reference _____

16. The two general classes of admixtures are _____ admixtures and _____ agents.

    Reference _____

CHAPTER 10
ACCESSORY MATERIALS

Objectives: To understand the use, purpose and installation of sealants, resins, bonding agents and other coatings.

Lesson Notes: New materials are continually being introduced. It is important that these materials be tested for their intended use prior to installation. An untested product can quickly become a detriment to what otherwise would be good quality concrete.

Key Points:

- Name the various kinds of field-molded sealants.
- Describe each of the following sealants as to composition and where used: mastics, hot-applied thermoplastics, chemically curing thermosetting sealants, solvent-release thermosetting sealants and rigid materials.
- What are preformed sealants?
- Name the three types, grades and classes of epoxy resin systems.
- Where are epoxy resin systems used?
- What are the temperature ranges, conditions, surfaces and applications of epoxy resin systems?
- What two components are usually part of an epoxy resin system?
- Name the advantages of bonding agents.
- As what are bonding agents usually classified?
- Describe the types of paints that can be used to improve durability, decorate concrete and make concrete water tight .
- What materials can be used for waterproofing and damp-proofing concrete?
- Why should plaster of paris not be used as a patching compound?
- Where would a surface retarder be used?

CHAPTER 10—QUIZZES

I Multiple Choice

1. _____ are thick liquids used where small joint movement is expected.

   a. Mastics
   b. Solvent-release thermosetting sealants
   c. Epoxies
   d. Thermoplastics
   e. Patching compounds

   Response _____ Reference _____

2. Epoxy resins will not normally adhere to _____ surfaces.

   a. wet
   b. metal
   c. wood
   d. concrete
   e. greased

   Response _____ Reference _____

3. Some rapid-setting cements contain _____, which causes a set within a few minutes.

   a. dehydrated gypsum
   b. hydrated lime
   c. epoxy resin
   d. mastic
   e. calcium chloride

   Response _____ Reference _____

4. Which one of the following materials is not a chemically-curing thermosetting sealant?

   a. polysulfide
   b. epoxy
   c. urethane
   d. silicone
   e. neoprene

   Response _____ Reference _____

5. Which one of the following is not an application in which epoxy resins are normally used with concrete?

   a. producing a skid-resistant surface
   b. bonding hardened concrete to other materials
   c. waterproofing and waterstops
   d. bonding plastic concrete to hardened concrete
   e. filling cracks

   Response _____ Reference _____

II True/False

6. Polyvinyl acetate, which improves the bond of concrete to old concrete, is a type of epoxy resin.

   T_____ F_____ Reference _____

7. A job-mixed paint to make concrete watertight is composed mainly of white Portland cement and calcium stearate.

   T_____ F_____ Reference _____

8. One method of exposing aggregate on the surface of concrete is to use a surface retarder.

   T_____ F_____ Reference _____

III Completion

9. Two methods of installing preformed sealants are to _____ the sealant in the concrete or by _____ the sealant into the joint slot.

   Reference _____

10. Sealants that are cured by release of a solvent include _____, _____ and _____.

    Reference _____

11. Epoxy resins are usually composed of two components, the basic _____and a_____.

    Reference _____

12. Rigid waterstops are usually made of _____; flexible waterstops are usually made of natural and synthetic _____and _____.

    Reference _____

CHAPTER 11
FORMWORK

Objective: To gain an understanding of the various materials used for forms and of the requirements for formwork, including bracing, shoring, form oils, cleanliness and removal.

Lesson Notes: All too frequently, failure that is due to inadequate formwork causes major loss of life or property. Not included in the latter are the unsightly conditions that occur when only part of a formwork is deficient. There is no substitute for well-designed forms.

Key Points:

- Name the 18 most common deficiencies that lead to the failure of forms.
- How could unsatisfactory alignment and concrete vibration affect forms?
- When are chamfer strips used?
- In what dimension is plywood strongest?
- How should tie rods and metal ties be placed?
- Describe how horizontal construction joints should be formed.
- Why camber forms?
- What is the most stable type of lumber for forms?
- Why not use green or kiln-dried lumber?
- What is coated plywood?
- In formwork, what is the most common use of glass fiber-reinforced plastic?
- What are the advantages of using plastic and rubber liners?
- What are the most common uses for steel forms?
- Of what are sonotube fiber forms made?
- Describe waste molds, their uses and the precautions necessary for good concrete.
- What is the most common form fastener?
- Describe each of the following and how they are used: form clamp, snap tie, coil tie, she-bolt and inserts.
- Why are forms treated with oil?
- Name the different types of materials used as form coatings.
- Name the two general classes of form coatings.
- How are chemically active coatings applied to forms?
- Define *falsework*, *permanent shores* and *reshores*.
- What criteria should govern the installation of reshores?
- Define *slipform*.
- Identify the two types of prefabricated forms and the materials of which they are made.
- Prior to placing concrete, what should be done to forms?
- What are the concerns related to metal chairs?
- What are the benefits of careful form removal after placing concrete?
- When can forms be removed?

CHAPTER 11—QUIZZES

I Multiple Choice

1. The most common material used for forms is _____.

   a. steel
   b. wood
   c. masonry
   d. hardboard
   e. sonotube

   Response _____ Reference _____

2. A _____ is made from multiple layers of heavy paper bonded together and impregnated with resin or wax to become water-repellent.

   a. slipform
   b. hardboard form
   c. flexible liner
   d. sonotube
   e. waste mold

   Response _____ Reference _____

3. Prefabricated forms that can be used for many applications are known as _____ forms.

   a. modular
   b. job specific
   c. slip
   d. spreader
   e. chamfer

   Response _____ Reference _____

4. Which one of the following is not used as a form oil or compound?

   a. wax
   b. lacquer
   c. plastic coatings
   d. motor oil
   e. shellac

   Response _____ Reference _____

5. A _____ is a movable form that is raised vertically as the concrete is placed.

   a. roller form
   b. reshore form
   c. self-adjusting form
   d. slipform
   e. none of the above

   Response _____ Reference _____

6. An assembly for a wall form that is composed of two nut washers, two waler rods and a central tie is a _____.

   a. form clamp
   b. snap tie
   c. she-bolt
   d. coil tie
   e. reshore tie

   Response _____ Reference _____

7. Overlay plywood can be used without _____.

   a. walers
   b. form oil
   c. chamfers
   d. bulkheads
   e. resin

   Response _____ Reference _____

8. _____ should be placed in the corners of forms to produce beveled edges on permanently exposed concrete surfaces.

   a. edge protectors
   b. chamfer strips
   c. steel liners
   d. form clamps
   e. walers

   Response _____ Reference _____

9. Vertical shoring under a beam or slab can be accomplished either with permanent shores or _____.

   a. slipshores
   b. precast shores
   c. reshores
   d. waste shores
   e. panel shores

   Response _____ Reference _____

II True/False

10. A snap tie is made of a single piece of wire cut to length and headed at each end.

    T_____ F_____ Reference _____

11. A waste mold is usually made of casting plaster reinforced with fiber and supported on wood framework.

    T_____ F_____ Reference _____

12. Clamps and pins should hold forms rigidly together in place and allow removal without damage to the concrete.

    T_____ F_____ Reference _____

13. Forms should be constructed to withstand a hydraulic head from fresh concrete of at least 250 pounds per lineal foot.

    T_____ F_____ Reference _____

14. The quality of lumber that is usually specified to be used for formwork is utility grade.

    T_____ F_____ Reference _____

15. Except for prefabricated forms, forms usually are not designed for reuse.

    T_____ F_____ Reference _____

III Completion

16. Forms for suspended slabs and beams are frequently cambered to allow for _____ or _____; a common allowance being _____ per 16 feet of _____.

    Reference _____

17. When placing a successive lift of concrete on previously placed and hardened concrete, the horizontal _____ between the two lifts is often a source of disfigurement that can be avoided by providing form _____ about _____ below the top of the _____.

    Reference _____

18. After stripping a form, it should have all _____ ,_____, _____, and _____ removed before reuse.

    Reference _____

19. When made, waste molds should be sized with _____ or _____ and coated with parting compound or _____ just prior to placing concrete.

    Reference _____

20. Prefabricated forms are held together with _____ and can be _____ and _____to form large areas.

    Reference _____

CHAPTER 12
PROPORTIONING THE CONCRETE MIXTURE

Objectives: To understand how to proportion materials in a concrete mixture and how to adjust the mix to maintain the required quality, and how to review the properties of materials and understand the selection of mix characteristics when tests or history are not available.

Lesson Notes: Give additional attention to the steps used to estimate mix proportions in Section 12.3.

- Key Points:
- Study Table 12.1 and note how changing the MSA affects a concrete mix.
- How are the ingredients of concrete mixes selected?
- In good quality concrete, what percentage of total ingredients does the paste occupy?
- How should mixes be proportioned?
- Why should a mix be adjustable?
- Regardless of the mix selected, what are the special exposure requirements that may have to be met?
- Define the following terms: *specific gravity*, *bulk specific gravity*, *density*, *voids*, *unit weight* and *absolute volume*.
- List the steps in establishing a trial mix.
- What are the limits of the MSA?
- What is the most common aggregate size for structural concrete?
- Name the controlling conditions when water-cement ratio is not specified.
- What does slump measure?
- On what does the total amount of mixing water for the required slump depend?
- Review the mix design example given on page 225 of the *Concrete Manual*.
- When using trial mixes, how many mixes are to be made in order to establish strength versus water-cement ratio?
- Describe the final adjustments to be made to a proposed mix.
- Review the example on page 233 of the *Concrete Manual*. What is the variable when using air entrainment?
- What variables are involved when using superplasticizers and fly ash? Review Section 12.5.
- What are relative yield and actual yield?
- What information should be supplied when ordering ready-mixed concrete?
- What are gap-graded mixes?
- Where are gap-graded mixes typically used?
- What might be the advantages of using gap-graded mixes?

CHAPTER 12—QUIZZES

I Multiple Choice

1. If the MSA in non-air-entrained concrete is 1 inch, the air content is 1.5 percent, and the volume of sand is 41 percent, the amount of water per cubic yard will be approximately _____ pounds.

   a. 280
   b. 300
   c. 325
   d. 340
   e. 355

   Response _____ Reference _____

2. Relative yield is the _____ divided by the designed sign of the batch.

   a. unit weight
   b. actual yield
   c. weight of all materials except admixtures
   d. water-cement ratio
   e. aggregate weight

   Response _____ Reference _____

3. All aggregate particles in concrete should be _____ .

   a. surrounded by paste
   b. moist prior to mixing
   c. added to the mix last
   d. clean, dry and segregated
   e. none of the above

   Response _____ Reference _____

4. Most aggregate is graded from the finest material to the MSA; in _____ grading, some sizes of aggregate are not used.

   a. gap
   b. batch
   c. selective
   d. stepped
   e. none of the above

   Response _____ Reference _____

5. If enough test results are not available for a statistical analysis of field tests, then it is necessary to make _____ to determine the concrete proportions.

   a. structural models
   b. strength value models
   c. a field analysis
   d. educated guesses
   e. laboratory trial batches

   Response _____ Reference _____

6. Which of the following material properties is not important when determining mix proportions?

   a. density
   b. unit weight
   c. voids
   d. durability
   e. specific gravity

   Response _____ Reference _____

7. When the water-cement ratio is constant and sources of ingredients differ, concrete strengths _____.

   a. are constant
   b. are higher
   c. do not vary
   d. are usually lower
   e. may vary

   Response _____ Reference _____

8. Non-air-entrained concrete with a maximum size aggregate of $^{3}/_{4}$ inch will have about _____ percent air content.

   a. 1.0
   b. 1.5
   c. 2.0
   d. 2.5
   e. 3.0

   Response _____ Reference _____

9. Concrete exposed to seawater must be made with Type _____ cement.

   a. I
   b. II
   c. III
   d. V

   Response _____ Reference _____

II True/False

10. The introduction of a high-range water reducer has not presented another variable in proportioning mixes.

    T_____ F_____ Reference _____

11. Each sack of ready-sacked concrete mix contains cement, fine aggregate and coarse aggregate; weighs either 60 or 100 pounds; and is ready to use by adding water.

    T_____ F_____ Reference _____

12. The normal procedures for mix proportioning can, in general, be applied when using no- slump concrete.

    T_____ F_____ Reference _____

13. Superplasticizers cannot be used successfully with fly ash.

    T_____ F_____ Reference _____

14. The ratio of the weight of a piece of aggregate of 1 cubic foot volume to the weight of 1 cubic foot of water is the bulk specific gravity.

    T_____ F_____ Reference _____

15. Two methods of arriving at the mix proportions for a job are the statistical method and the use of laboratory trial batches.

    T_____ F_____ Reference _____

16. The total amount of mixing water per cubic yard of concrete is significantly affected by the cement content but is not affected by temperature.

    T_____ F_____ Reference _____

17. The water-cement ratio selected for mix design must be the highest value required to meet anticipated exposure conditions.

    T_____ F_____ Reference _____

III Completion

18. When test and history information is not available, estimates of mix proportions can be determined by following a number of steps, the first of which is to select the _____ from the specifications or based on the _____ conditions.

    Reference _____

19. There are two kinds of voids, those_____ the aggregate and those that are _____ aggregate particles.

    Reference _____

20. The MSA of any mix should not exceed one-third of the _____ of

a slab, _____ of the minimum clear reinforcement spacing or between reinforcing and the _____ , nor _____ the narrowest dimension between form sides.

Reference _____

21. When selecting a mix using the aggregate content percentage method, _____ batches should have compressive strength tested with _____ cylinders at _____ , _____ and _____ days.

    Reference _____

22. When proportioning mixes, the effects of admixtures on _____ and _____ of concrete must be taken into consideration.

    Reference _____

23. Concrete that will be exposed to seawater must be made with _____ cement, with a water-cement ratio not exceeding _____ , with a corresponding minimum specified strength of _____ .

    Reference _____

CHAPTER 13
TESTING AND CONTROLLING THE CONCRETE

Objectives: To understand why testing is needed, the types of tests conducted on fresh concrete and how they are taken, the curing and testing of strength cylinders, methods of rapid strength gain, and the sampling and testing methods used on hardened concrete.

Lesson Notes: Although extensive knowledge of testing procedures for concrete is not necessary for everyone, the basics should be known so that we understand the importance and objectives of testing.

Key Points:

- What adjustments to a mix might be necessary under field conditions?
- What factors may contribute toward needing to adjust the amount of water in a mix so as to maintain a consistent slump?
- Define *sample*.
- What is the basic requirement when sampling concrete?
- What occurs when a sample is not representative of the concrete?
- What is the purpose of laboratory and field testing?
- Why are tests necessary?
- Why take more than one test?
- On page 242 of the *Concrete Manual* there are two statements: “Testing is a precise operation” and “An improperly made test is worse than no test at all.” Why are these statements true?
- When might a nonstandard test be appropriate?
- There are two groups of tests for concrete. Identify the tests that belong to each group.
- Describe the method for obtaining samples of fresh concrete.
- How often should samples be taken?
- What does a slump test determine?
- How is slump measured?
- List the steps in taking a slump test.
- Why take the temperature of fresh concrete?
- Where can the temperature test be made?
- When should air content tests be taken?
- Name the two types of air meters.
- What is the main source of errors in these meters, and how can errors be avoided?
- What information does a concrete strength specimen provide?
- What is the most common size of a specimen cylinder?
- After making strength specimens, how are the cylinders handled?
- Under what conditions can specimens be stored at a job site?
- Why might job-site curing be done?
- How are specimens stored in the laboratory?
- Describe the precautions to be observed when the cylinder is capped.
- When a specimen has a low strength, what visual observations might give an indication of the cause?

- Identify some of the methods of measuring strength gain.
- What do all these tests have in common in relationship to the 28-day strength?
- When are tests made on hardened concrete?
- What is the most common method of sampling hardened concrete?
- Describe the concerns when taking core samples.
- For what other purposes might core samples be taken?
- After core samples are obtained, how should they be treated and handled?
- How are cores dressed?
- Name the two methods of testing concrete in-place.
- How is a Swiss hammer calibrated?
- In what ways is the accuracy of a Swiss hammer affected?
- When using a Swiss hammer, how many readings are taken?
- Briefly describe how a Windsor probe works.

CHAPTER 13—QUIZZES

I Multiple Choice

1. In general, when total water in a mix is increased by _____ percent, the slump will increase about 1 inch.

   a. one
   b. five
   c. two
   d. ten
   e. t h r e e

   Response _____ Reference _____

2. Which of the following is not included as a mixer performance test for uniformity of concrete?

   a. slump
   b. unit weight
   c. strength
   d. air content
   e. none of the above

   Response _____ Reference _____

3. To properly perform a test, it is necessary to _____ .

   a. follow standard methods
   b. have it be performed by qualified persons
   c. properly interpret the results
   d. use the proper equipment
   e. all of the above

   Response _____ Reference _____

4. The most common size of a compressive strength cylinder is _____.

   a. 4-inch x 8-inch
   b. 6-inch x 12-inch
   c. 8-inch x 12-inch
   d. 4-inch x 12-inch
   e. 8-inch x 6-inch

   Response _____ Reference _____

5. When taking a slump test, the slump cone should be filled in _____ equal volumes.

   a. two
   b. three
   c. four
   d. five
   e. none of the above

   Response _____ Reference _____

6. The most common method of sampling hardened concrete is by _____ .

   a. sampling a broken piece from the structure
   b. using a Swiss hammer
   c. using a Windsor probe
   d. extracting cores
   e. none of the above

   Response _____ Reference _____

7. Which of the following will aid in reducing the water-cement ratio?

   a. reduce the percentage of sand
   b. use larger-sized coarse aggregate
   c. use an air-entraining agent
   d. improve the sand grading
   e. all of the above

   Response _____ Reference _____

8. When testing compressive strength cylinders in the laboratory, the cylinders should be _____ .

   a. at room temperature
   b. between 60ºF and 80ºF
   c. between 50ºF and 80ºF
   d. immersed in water
   e. treated with oil

   Response _____ Reference _____

9. Compressive strength tests should be made at a location where they will be undisturbed for at least _____ hours.

   a. 8
   b. 12
   c. 24
   d. 36
   e. 48

   Response _____ Reference _____

10. A Swiss hammer has an accuracy of between _____ percent, depending on how well it is calibrated.

    a. 2 and 3
    b. 5 and 10
    c. 10 and 20
    d. 5 and 8
    e. 15 and 20

    Response _____ Reference _____

11. Maturity methods can be an effective means to determine adequate strength for _____ .

    a. form removal
    b. post-tensioning work
    c. sawing joints in slabs-on-grade
    d. controlling accelerated heat curing methods
    e. all of the above

    Response _____ Reference _____

12. When the lab technician measures and reports 7-day versus 28-day strength data for concrete test cylinders, the technician is reporting _____ .

    a. durability data
    b. frequency data
    c. maturity data
    d. petrographic data
    e. none of the above

    Response _____ Reference _____

13. The 4-inch by 8-inch test cylinder _____.

    a. is easier to cast
    b. requires less sample
    c. is easier to handle
    d. requires less field curing space
    e. all of the above

    Response _____ Reference _____

II True/False

14. In general, the strength of extracted cores is lower than the strength of standard cylinders tested at an identical age.

    T_____ F_____ Reference _____

15. Tests do three things: they reveal the quality of a product, they show how uniform the product is, and they verify the total volume.

    T_____ F_____ Reference _____

16. A Windsor probe will measure hardness to a greater depth than a Swiss hammer.

    T_____ F_____ Reference _____

17. There are two types of air meters in regular use: pressure and volumetric.

    T_____ F_____ Reference _____

18. When using a Swiss hammer, it is usual practice to take 15 readings and average them together.

    T_____ F_____ Reference _____

19. An abnormally low unit weight indicates either a high air content or excessive water.

    T_____ F_____ Reference _____

20. Most procedures for rapid strength measurement rely on heat to accelerate hydration.

    T_____ F_____ Reference _____

21. Before maturity of job-placed concrete can be determined, a maturity curve for the specific concrete mix must be developed in the laboratory.

    T_____ F_____ Reference _____

22. The difference in compressive strength between the 4-inch by 8-inch and 6-inch by 12- inch test cylinder size is insignificant.

    T_____ F_____ Reference _____

23. Concrete cylinders cast in place in cylinder molds provide a means for determining the in-place compressive strength of concrete.

    T_____ F_____ Reference _____

III Completion

24. Slump is measured in _____; a _____ slump indicates a stiff or dry consistency, a _____ slump indicates a soft or wet consistency.

    Reference _____

25. Because important decisions are based on tests results, strict and undeviating _____ of the specific procedures will achieve _____ and _____ .

    Reference _____

26. A change in coarse aggregate grading may affect the percentage of_____ and the rodded _____ of the aggregate, which is reflected in a change in the amount of sand required.

    Reference _____

27. Concrete used in an air meter in which water is used to fill the container should not be used for _____ tests or _____ specimens.

    Reference _____

28. Tests performed on hardened concrete are made in order to _____ or _____ the quality of the hardened concrete.

    Reference _____

29. The basic requirement of any sampling procedure is to obtain a truly _____ sample of the concrete.

    Reference _____

CHAPTER 14
BATCHING AND MIXING THE CONCRETE

Objectives: To understand how materials for concrete are to be handled, the types of batching and control systems in current use, and the types of mixers. Also reviewed are the history, operation and control of ready-mixed concrete, as well as the responsibilities of those involved in all aspects of concrete construction.

Lesson Notes: Size is not a qualifier for the quality mixing of concrete. Quality control may in fact be easier to achieve with smaller batches as opposed to a large operation in which one mistake can result in hundreds of yards of defective concrete.

Key Points:

- Define *fine aggregate*.
- What is the difference between natural and manufactured sand?
- What is the purpose of finish screening?
- How might coarse aggregate be contaminated?
- Why should special precautions be taken when taking aggregates from the bottom of a pile?
- How should admixtures be stored?
- At what point are superplasticizers usually introduced into a mix?
- How are pozzolans handled?
- Describe the types of control systems used at a batch plant.
- Of what does a partially automated batching system consist?
- Of what does a semiautomatic batching system consist?
- Describe the operation of an automatic batching system.
- What is the function of a recorder?
- Name the types of recorders.
- How accurate does a recorder have to be?
- In addition to the recording of plant operations, what other information can be obtained from a recorder?
- Describe the steps in calibrating a moisture meter.
- What is another name for a consistency meter?
- How does a consistency meter work?
- Why is weighing the cement first on a cumulative scale unacceptable?
- Identify the ways in which batching can be done.
- Describe the various ways that an admixture is batched.
- On what should the batch weights of aggregate be based?
- Name the causes of slump variations.
- What is the reason for having a batching sequence?
- Why is it important to check the accuracy of scales and batchers?
- Define *suspense material*.
- Name the different types of mixers and how they operate.
- What type of mixer is a turbine mixer?
- Name the advantages of a turbine mixer.
- Can a mixer be overloaded?

- List the causes of cement balls.
- Name the causes of incomplete mixing.
- Why install a timing device on a mixer?
- Define *ready-mixed concrete*.
- List the factors that are significant in batching and mixing of ready-mixed concrete.
- Name the three types of truck mixers.
- Which of these is a nonagitating type?
- What are the maintenance concerns of a mixer?
- Describe the operation of a mobile batcher.
- What are the advantages of a mobile batcher?
- Define *ribbon loading* and how it works.
- Describe what the sequence should be when adding materials to a mixer.
- During the trip to the job site, what is the speed of the truck mixer?
- Why is overmixing detrimental?
- Define what is meant by *agitating speed*.
- What is included when considering the total water?
- Should wash water be allowed as part of mixing water?
- Describe how water should be added after a truck has left the batch plant. When during or after discharge may water be added to a batch?
- List the information that should be included on a load ticket.
- Does air content increase or decrease with extended mixing?
- What is the generally agreed-on maximum time frame for mixing?
- How is delayed mixing accomplished?
- Give a brief description of the producer’s and contractor’s responsibilities, as well as their joint responsibilities.

CHAPTER 14—QUIZZES

I Multiple Choice

1. Aggregates at the bottom of a pile may be unsuitable because of the intrusion of _____.
   a. water
   b. foreign matter
   c. paste
   d. other aggregates
   e. e.fines

   Response _____ Reference _____

2. A moisture meter usually consists of _____ electrode(s).
   a. one
   b. two
   c. three
   d. four
   e. none of the above

   Response _____ Reference _____

3. Which one of the following is not required on the load ticket?
   a. serial number of the ticket
   b. amount of concrete
   c. MSA
   d. name of the contractor
   e. job name and location

   Response _____ Reference _____

4. The primary function of a recorder is to _____ .
   a. check the mix design
   b. make a permanent record of plant operation
   c. verify the quality of materials
   d. indicate the accuracy of the weight and amount of cement
   e. provide quality control

   Response _____ Reference _____

5. One of the concrete producer’s responsibilities is to _____ .
   a. perform required tests
   b. organize placement and prompt discharge
   c. proportion and batch to meet specifications
   d. provide information on quantity required
   e. all of the above

   Response _____ Reference _____

6. The use of ready-mixed concrete became widespread after _____.
   a. 1909
   b. 1920
   c. 1930
   d. 1940
   e. 1960

   Response _____ Reference _____

7. The main advantage of a mobile batch mixer is_____.
   a. accurate mixing
   b. quality control of materials
   c. ease of delivery
   d. portability
   e. all of the above

   Response _____ Reference _____

8. Fine aggregate is material that passes a No. _____sieve.
   a. 4
   b. 5
   c. 8
   d. 9
   e. 12

   Response _____ Reference _____

9. A mixer with a rotating drum that charges, mixes and discharges with its drum axis horizontal is a _____ .
   a. plant mixer
   b. vertical shaft mixer
   c. horizontal shaft mixer
   d. tilting mixer
   e. nontilting mixer

   Response _____ Reference _____

10. The agreed upon length of time that cement can be exposed to moisture in a mixer is _____.
    a. one hour
    b. one and one-half hours
    c. two hours
    d. two and one-half hours
    e. three hours

    Response _____ Reference _____

II True/False

11. Aggregates at the bottom of a stockpile located on ground can be used without concern.

    T_____ F_____ Reference _____

12. Batch plants that handle more than one type of cement should have each type in a separate compartment.

    T_____ F_____ Reference _____

13. A ready-mixed concrete producer provides the personnel and equipment to ensure continuous production at a rate that meets the needs of the work.

    T_____ F_____ Reference _____

14. When used, a superplasticizer must be introduced into the mixer immediately before discharge of the concrete into the receiving equipment.

    T_____ F_____ Reference _____

15. Trucks used to supply ready-mixed concrete to the job site must be cleaned so that concrete will not accumulate on the drum or around the mixing blades.

    T_____ F_____ Reference _____

16. If water is not added, long-time mixing will not affect slump or stiffness.

    T_____ F_____ Reference _____

17. The suggested mixing time for a 4 cubic-yard stationary mixer is about three minutes.

    T_____ F_____ Reference _____

18. The direction of rotation of the drum on a truck-mixer is reversed to discharge the concrete.

    T_____ F_____ Reference _____

III Completion

19. The method of _____and _____ the cement and aggregates into the _____ has a very important influence on the efficiency of mixing.

    Reference _____

20. When batching, cement must be weighed_____ ; aggregates may be _____, weighing each in turn; and if weighed, water should be weighed on _____.

    Reference _____

21. Control systems range from manually controlled individual batchers that depend on the operator's visual observation of a _____ or _____ to fully automated systems that are actuated by a single starting _____ and that stop automatically when the _____ has been reached.

    Reference _____

22. Total water in concrete includes free water on the_____, _____ in admixtures, _____ used in hot weather and water added to the batch.

    Reference _____

23. To promote thorough mixing inside a drum mixer, the _____ should be designed to move the concrete from _____ end of the drum to the_____, with many crossing of _____.

    Reference _____

24. There are two potential sources of trouble when aggregate is delivered to the plant by _____ :placing the _____ material in a pile, and _____ and _____ being carried into the pile by the truck.

    Reference _____

25. A few of the items that are included on a ready-mixed load ticket are the date, _____ number, name of the _____ and the _____, amount of _____, and time _____.

    Reference _____

26. Scales and batching equipment should be kept_____. Binding of _____or _____ knife edges and _____ causes serious weighing errors.

    Reference _____

27. The three methods of mixing ready-mixed concrete are _____ , _____ , and _____.

    Reference _____

CHAPTER 15
HANDLING AND PLACING THE CONCRETE

Objectives: To understand the preparation needed prior to placing concrete, the various ways of conveying and pumping concrete, and the proper placement and consolidation of concrete.

Lesson Notes: When depositing concrete in the forms, the term most commonly used is *pouring*; however, *placing* is the more correct term and is more accurate insofar as pouring applies only to a liquid. The use of the word *pouring* originated in the days when wet, sloppy concrete was permitted to flow into place.

Key Points:

- What are the three phases of placing concrete?
- How are cast-in-place piles and caissons inspected?
- When may a construction joint be required?
- Is roughness necessary for a good construction joint?
- Does reinforcing usually continue through a construction joint?
- How is a shear key formed?
- Describe the factor that can cause laitance at a construction joint.
- When may embedded items be placed in plastic concrete?
- What factors must be considered when choosing conveying equipment?
- Identify the advantages and disadvantages of direct discharge.
- What is one of the chief considerations when placing concrete?
- How should concrete be discharged vertically?
- Name the three types of concrete pumps.
- How does aggregate grading affect pumping?
- List the admixtures that improve pumpability.
- What is the best slump for pumping concrete?
- What is the most common aggregate size when pumping concrete?
- How does pumping affect slump?
- What concerns are associated with keeping concrete in a pump hopper?
- What are the causes of line blockage, and how can they be avoided?
- Describe the problems with downhill pumping.
- What is the main problem in pumping lightweight concrete?
- From where does the term *pouring* originate?
- State the basic rule of placing concrete.
- Name the types of equipment used to deposit concrete.
- How quickly should concrete be placed?
- Describe how concrete should be placed in walls of considerable height.
- How should concrete be placed in deep footings or piles?
- Give a brief description of how best to place monolithic columns and slabs.
- Why should concrete not be placed during a heavy rain?
- What precautions are necessary when placing concrete after rain has started?
- Name the two kinds of vibrators.
- Is vibration always required?

- Against what should a vibrator not be placed?
- How would you handle concrete that has segregated?
- Is overvibration ever a problem?
- When can concrete be revibrated?

CHAPTER 15—QUIZZES

I Multiple Choice

1. A good concrete mix for pumping is a plastic, workable mix with a slump range between _____ inches.

   a. 3 to 6
   b. 4 to 6
   c. 4 to 8
   d. 5 to 7
   e. 2 to 5

   Response _____ Reference _____

2. Chutes can be made of _____ .

   a. wood
   b. metal
   c. plastic
   d. aluminum
   e. any of the above

   Response _____ Reference _____

3. One problem associated with belt conveyors is _____ .

   a. segregation
   b. consolidation
   c. mortar leakage
   d. motor failure
   e. all of the above

   Response _____ Reference _____

4. Forms should be clean, tight and _____ .

   a. wet
   b. staked
   c. properly braced
   d. supported by earth
   e. all of the above

   Response _____ Reference _____

5. Vibrators can be grouped into two classes: _____ .

   a. mechanical and electrical
   b. external and internal
   c. pneumatically driven and electrical
   d. pan and screed
   e. table and shaft

   Response _____ Reference _____

6. The most commonly used aggregate in a pump mix is _____ inch(es).

   a. $^{3}/_{4}$ or 1
   b. 1 or $1^{1}/_{4}$
   c. 1 or $1^{1}/_{2}$
   d. $1^{1}/_{2}$ or 2
   e. pea gravel

   Response _____ Reference _____

7. High-frequency vibration for consolidation of concrete was introduced around _____ .

   a. 1950
   b. 1945
   c. 1940
   d. 1935
   e. 1930

   Response _____ Reference _____

8. Prior to placing concrete when using a pump, the hose should be _____ .

   a. primed with water
   b. straight and without radius, bends or kinks
   c. kept at pump level
   d. lubricated with form oil
   e. primed with mortar

   Response _____ Reference _____

9. When using a wheelbarrow to transport concrete, the maximum horizontal distance should be _____ feet.

   a. 100
   b. 150
   c. 175
   d. 200
   e. 250

   Response _____ Reference _____

10. Conveyor belts for placing concrete have an average capacity of about _____ cubic yards per hour.

    a. 20 to 30
    b. 30 to 40
    c. 40 to 50
    d. 50 to 60
    e. 60 to 70

    Response _____ Reference _____

11. Proper consolidation of concrete decreases _____ .

    a. cold joints
    b. honeycombing
    c. entrapped air
    d. segregation
    e. all of the above

    Response _____ Reference _____

12. Concrete is properly vibrated when _____ .

    a. concrete surface takes on a sheen
    b. large air bubbles no longer appear at surface
    c. vibrator changes pitch or tone
    d. large aggregate blends into surface
    e. all of the above

    Response _____ Reference _____

II True/False

13. Revibration occurs when the vibrator, in consolidating a layer of concrete, penetrates into the layer below to unite the two layers.

    T_____ F_____ Reference _____

14. When pumping concrete during an extended delay, it is not good practice to run the pump every few minutes.

    T_____ F_____ Reference _____

15. There are two types of piston pumps: hydraulic and mechanical.

    T_____ F_____ Reference _____

16. When using a bucket to place concrete, the bucket should have a capacity of at least one batch.

    T_____ F_____ Reference _____

17. Prior to placing concrete, excavations for foundations should extend into sound, undisturbed soil or rock.

    T_____ F_____ Reference _____

18. The most common width of a conveyor belt used to place concrete is about 24 inches.

    T_____ F_____ Reference _____

19. When using wood forms for blockouts, the wood should be clean and dry prior to placing the concrete.

    T_____ F_____ Reference _____

20. If it begins to rain before concrete placement has been completed, cover the work area with tarps until the concrete has set.

    T_____ F_____ Reference _____

21. Vibrators that are attached to forms and that vibrate the concrete by vibrating the forms are external-type vibrators.

    T_____ F_____ Reference _____

22. Sites that are especially suited for pumping of concrete are those where access is limited or that are crowded with materials.

    T_____ F_____ Reference _____

23. A thin coating of rust on reinforcing steel is detrimental, and dried mortar splashed on the steel must be removed.

    T_____ F_____ Reference _____

24. Hauling buckets on trucks for a considerable distance can cause segregation of the concrete.

    T_____ F_____ Reference _____

25. When vibrating formed concrete, the vibrator should be tilted slightly after contacting bottom of form.

    T_____ F_____ Reference _____

26. To avoid over vibration, a vibrator should be lifted rapidly from the concrete after each insertion.

    T_____ F_____ Reference _____

27. Revibration of concrete is acceptable if the vibrator can easily be pushed into the concrete.

    T_____ F_____ Reference _____

III Completion

28. Roughness is not essential to a good construction joint. A better joint is achieved if the surface of the old concrete is _____ and _____ .

    Reference _____

29. Essential to any system of moving concrete from a mixer to forms is to minimize _____ , prevent loss of _____ and avoid excessive loss of _____ .

    Reference _____

30. In difficult locations, such as on a steep hillside, a pump can easily move the concrete over _____ that would be difficult for a truck to reach.

    Reference _____

31. Cause of line blocks are slump to _____; harsh, unworkable _____ ; a mix that is too _____ ; bleeding of the concrete; a long line exposed to the _____ ; and a long interruption in _____ .

    Reference _____

32. A vibrator should not come into contact with the _____ or held against the _____ .

    Reference _____

33. With few exceptions, placing of _____ , _____ , _____ , and _____ should be done prior to concrete placement.

    Reference _____

34. Pumps are currently available with capacities in excess of _____ cubic yards per hour, _____ feet vertically and _____ feet horizontally.

    Reference _____

35. Vibrators should be placed at points that are uniformly _____ close enough together to ensure _____ and for _____ seconds duration per insertion.

    Reference _____

CHAPTER 16
SLABS ON GROUND

Objectives: To gain an understanding of the requirements for correct placing of concrete on all types of slabs, including suspended slabs.

Lesson Notes: One does not know concrete unless one knows “Slabs on ground”. They are never problem free… shrinkage, not strength, is the primary problem. If the reader deals primarily with construction of slabs on ground, a thorough understanding of the following “Key Points” is essential.

Key Points:

- What is the most important property of a slab on ground?
- How must the subgrade be prepared?
- What types of soils should be avoided in the subgrade?
- How essential is good drainage to sidewalks, floors and patio slabs?
- What is a screed?
- What is the difference between a screed and a wet screed?
- What is the recommended slope for interior and exterior slabs requiring drainage?
- When is a vapor barrier required?
- What material is normally used as a vapor barrier?
- How should a vapor barrier be installed?
- When would a vapor barrier not be required?
- When should slab on ground concrete be air-entrained?
- Describe the condition of the subgrade prior to placing concrete.
- When is concrete ready for final finishing?
- What are a darby, bullfloat, tamper and jitterbug?
- When should a tamper or jitterbug not be used?
- What is the primary function of joints in slabs?
- Name the three types of joints and their purpose.
- When are construction joints used?
- What is used when a bond across a joint is required?
- What can happen if dowels are not placed perpendicular to the bulkhead?
- When are contraction joints used?
- What is another name for contraction joints?
- Describe four methods for placing contraction joints.
- When a mix has normal shrinkage characteristics, at what distance should contraction joints be placed?
- When are isolation joints used?
- What is another name for an isolation joint?
- How is an isolation joint installed?
- Define *light-duty floor*.
- Describe the acceptable ways of installing wire mesh in medium-duty slabs.
- What are the strength and slump requirements for a medium-duty floor?
- Define *two-course heavy-duty floors*.
- How is wear resistance obtained for a heavy-duty floor?

- What is expansive soil, and how does it react with water?
- Define *suspended slabs*.
- How do the placing procedures for a suspended slab differ from those for a ground slab?

CHAPTER 16—QUIZZES

I Multiple Choice

1. A concrete floor that is not exposed to heavy loads or to an aggressive environment is a _____ floor.

   a. light-duty
   b. medium-duty
   c. heavy-duty
   d. special-duty
   e. none of the above

   Response _____ Reference _____

2. The maximum recommended slump of a medium-duty floor is _____ inches.

   a. 2
   b. 3
   c. 4
   d. 5
   e. 6

   Response _____ Reference _____

3. The subgrade must be prepared by removing _____ .

   a. grass
   b. roots
   c. organic matter
   d. soft soil
   e. all the above

   Response _____ Reference _____

4. A floor slab where industrial vehicular traffic is anticipated should have a _____ finish.

   a. single trowel
   b. float
   c. broom
   d. hard steel trowel
   e. rake

   Response _____ Reference _____

5. Isolation joints allow a slab to _____.

   a. move vertically
   b. move horizontally
   c. move vertically and horizontally
   d. expand
   e. none of the above

   Response _____ Reference _____

6. An interior floor slab should _____ if moisture is present under it.

   a. be built on a vapor barrier
   b. have a 2-inch sand barrier
   c. be built with Type V cement
   d. have adequate subdrains
   e. none of the above

   Response _____ Reference _____

7. When placing concrete, the final compacting following the strike-off is accomplished by the use of a _____ .

   a. screed
   b. bullfloat
   c. rake
   d. jitterbug
   e. tamper

   Response _____ Reference _____

8. When installing contraction joints, the groove edges should be _____ .

   a. squared
   b. slightly rounded
   c. tapered
   d. angled
   e. any of the above

   Response _____ Reference _____

9. Where installed in a slab, reinforcing should be supported by _____ .

   a. pieces of stone
   b. metal stakes
   c. wood supports
   d. chairs
   e. any of the above

   Response _____ Reference _____

10. Spacing of contraction joints should not exceed _____ times the slab thickness where normal shrinkage is anticipated.

    a. 20
    b. 30
    c. 40
    d. 50
    e. 60

    Response _____ Reference _____

II True/False

11. When a new slab is placed adjacent to existing concrete, there must be a separation to allow for movement relative to the old concrete.

    T_____ F_____ Reference _____

12. When a slab is water soaked for much of the time, a nonpermeable layer should be installed for a depth of 6 inches.

    T_____ F_____ Reference _____

13. Rakes, shovels and hoes are acceptable for spreading concrete.

    T_____ F_____ Reference _____

14. The thickness of a medium-duty, one-course floor slab is determined on the basis of the strength and slump of the concrete used.

    T_____ F_____ Reference _____

15. After a good floor has been properly cured, its durability cannot be improved by further drying.

    T_____ F_____ Reference _____

16. A floor in a dwelling that is intended to be covered by carpet should be of the same hardness quality as a warehouse floor.

    T_____ F_____ Reference _____

17. The primary function of most joints in concrete is to control or minimize cracking and other volume changes, or to permit relative movement of adjacent portions in a structure.

    T_____ F_____ Reference _____

18. The drying shrinkage of the concrete in a large slab will cause random cracks in the slab unless means are provided to relieve this stress.

    T_____ F_____ Reference _____

19. Premolded material in an expansion joint must be at least one-half as wide as the slab is thick and may extend slightly above the slab.

    T_____ F_____ Reference _____

20. A deep keyway for keyed construction joints is preferable to ensure complete filling of the keyway when the second run of concrete is placed.

    T_____ F_____ Reference _____

III Completion

21. A suspended slab is one that does not require support by the _____ and must meet the structural requirements of the _____ .

    Reference _____

22. A wet screed is a strip of concrete about _____ inches wide that is placed just before placing concrete for the slab.

    Reference _____

23. Prior to placing a concrete slab, the subgrade should be saturated for _____ before and _____ at the time concrete is to be placed.

    Reference _____

24. When floors must be sloped for drainage, interior slabs should have a slope of at least _____ inch per _____ , and exterior slabs should have at least _____ inch per _____. Anything less is likely to result in _____ .

    Reference _____

25. In locations where concrete placing is discontinued, a _____ should be installed and a _____ made. The location of construction joints on a large slab should be _____ .

    Reference _____

26. The effect of adequate cement on the durability of a floor can be nullified by a lack of _____ , high _____ , over-vibration or working the surface when _____ is present.

    Reference _____

CHAPTER 17
FINISHING AND CURING THE CONCRETE

Objectives: To understand the proper application and use of concrete finishing tools and the wear resistance, special treatments and decorative finishes for floors. The materials, time and methods of curing will be reviewed as well.

Lesson Notes: Improper curing can ruin what otherwise would be good quality concrete. Unfortunately, it is often neglected or done improperly, thus reducing durability and structural adequacy. Conscientiously following proper curing procedures will result in good, durable concrete. Additionally, finishing, if hurried, can turn an attractive product into an unsightly mess.

Key Points:

- When should slab finishing operations begin?
- State the basic law of finishing concrete.
- Do all slabs require edging?
- Describe the purpose of edging.
- At what point is grooving begun?
- Name the important points of the correct method of grooving.
- What is the third step in finishing?
- When should floating start?
- What is the purpose of floating?
- Which material is best for floats?
- Name the last step in finishing concrete.
- What is the best type of finishing trowel.
- How is the first troweling done?
- How can smoothness of the concrete surface be improved?
- How should bubbles and blisters be treated when troweling?
- Describe the methods, besides brooming or brushing, of applying a nonslip finish to concrete.
- What is the hardness factor of concrete?
- Define *dusting*.
- What are the causes of dusting?
- Describe the chemical treatment processes for hardening of a concrete floor that is dusting.
- What is meant by a *dry shake coat*?
- What is the purpose of a dry shake coat?
- Name the materials used in dry shake coatings.
- How do liquid hardeners work?
- Should liquid hardeners be considered for any floor slab?
- Name two ways a travertine surface can be obtained.
- Describe how simulated flagstone is made.
- Identify the three methods for imparting color to concrete.
- Name the materials involved in the dry shake method of coloring concrete.
- Describe the two methods employed for creating exposed aggregate concrete.

- Briefly describe how to obtain exposed aggregate concrete using the integral and seeding methods.
- Why would a retarder be used in the integral method?
- What should be the MSA in an exposed aggregate slab when the seeding method is used?
- What is terrazzo?
- Describe how a sand-cushion terrazzo concrete floor is installed.
- What are the similarities and differences between a sand-cushion and a bonded terrazzo floor?
- How do dividers control cracking?
- What can occur if concrete is not properly cured?
- What does curing do?
- Over what period of time should concrete curing extend?
- Name the four methods of curing.
- What is the minimum thickness of polyethylene film used for curing concrete?
- Why is continual stirring of sealing compounds required?
- What time period is most crucial in concrete curing?
- What are the minimum curing times for various cements?
- What are the two general categories of curing methods? Which method is best?
- Give the positive and negative aspects of the methods of curing that supply added moisture.
- Briefly describe how wet burlap, spray pipes, flooding, wet earth and cotton mats are used to cure concrete.
- Name four common materials used for wet curing with blankets or mats.
- When is brush application of sealing materials acceptable?
- What is *Confilm*, and how is it applied?
- What is the usual temperature range of high-temperature curing?
- Identify the concerns when using high-temperature curing.
- What is steam curing?

CHAPTER 17—QUIZZES

I Multiple Choice

1. Prior to being subjected to high-temperature curing, concrete should undergo a presetting period after casting of between _____ at normal temperatures.

   a. 1 to 2 hours
   b. 2 to 3 hours
   c. 24 to 48 hours
   d. 48 to 72 hours
   e. 1 to 2 weeks

   Response _____ Reference _____

2. When exposing aggregate, which of the following should not be done?

   a. using calcium chloride in the concrete
   b. using a surface retarder
   c. testing a sample panel under field conditions
   d. using uniform materials
   e. none of the above

   Response _____ Reference _____

3. When a heavy-duty topping is required and placement has been delayed, the base slab should be _____ .

   a. clean
   b. moist
   c. dry
   d. both a and b
   e. both a and c

   Response _____ Reference _____

4. Curing methods that prevent loss of moisture entail use of _____ .

   a. retarders
   b. insulators
   c. sealing materials
   d. mats and blankets
   e. none of the above

   Response _____ Reference _____

5. After floating, the next step in the finishing process is _____.

   a. troweling
   b. grooving
   c. edging
   d. brooming
   e. none of the above

   Response _____ Reference _____

6. The best use of liquid hardeners is on _____.

   a. cured floors
   b. new floors
   c. above-grade slabs
   d. older floors
   e. all of the above

   Response _____ Reference _____

7. After grinding, a standard terrazzo topping should have a minimum thickness of at least _____ inch(es).

   a. 1 $^{1}/_{4}$
   b. 1
   c. $^{3}/_{4}$
   d. $^{5}/_{8}$
   e. $^{3}/_{8}$

   Response _____ Reference _____

8. The normal range of temperatures for high temperature curing is _____ ^{o}F.

   a. 120 to 160
   b. 100 to 125
   c. 150 to 200
   d. 125 to 170
   e. 175 to 225

   Response _____ Reference _____

9. _____ solutions are not to be used for curing concrete.

   a. Potassium chloride
   b. Sodium sulfate
   c. Calcium chloride
   d. Sodium silicate
   e. all of the above

   Response _____ Reference _____

10. All concrete must be _____ .
    a. finished
    b. cured
    c. edged
    d. treated
    e. all of the above

    Response _____ Reference _____

11. Unformed concrete surfaces include_____ .
    a. floors
    b. slabs
    c. sidewalks
    d. driveways
    e. all of the above

    Response _____ Reference _____

12. One result of dusting a partly hardened slab with dry cement can be _____.
    a. retarded setting
    b. dry shaking
    c. increased hardness
    d. bubbles
    e. all of the above

    Response _____ Reference _____

II True/False

13. Dusting is caused by weak and soft concrete that results from overfinishing, the use of overly fluid mixes or working the surface while bleed water is present.

    T_____ F_____ Reference _____

14. In a heavy-duty slab, joints in the base slab must be continuous through the wearing course; otherwise the topping will crack.

    T_____ F_____ Reference _____

15. A basic law of finishing concrete is to never use any tools on the fresh concrete while bleed water is present on the surface.

    T_____ F_____ Reference _____

16. Two of the optimum conditions for high-temperature steam curing are dry steam and a slow temperature rise of not over 60ºF per hour.

    T_____ F_____ Reference _____

17. Curing compounds are dry mixed when they arrive on the job and should not be agitated after initial mixing.

    T_____ F_____ Reference _____

18. Lean concrete in massive structures requires about four weeks for curing if pozzolans are not used. Normal concrete is best cured for seven days.
    T_____ F_____ Reference _____

19. When exposing aggregate, care must be taken to clean the aggregates without undercutting or loosening them. The maximum exposure is about $^{1}/_{16}$ to $^{1}/_{4}$ inch.
    T_____ F_____ Reference _____

20. Varnish, lacquers, shellac and surface waxes should not be used on terrazzo.
    T_____ F_____ Reference _____

21. When giving a rock salt finish, the salt is spread on the surface of the concrete at a rate of between 5 and 20 pounds per 100 square feet of area after the slab is finished in the normal manner.
    T_____ F_____ Reference _____

22. A new trowel is difficult to use until it has been broken in for a few weeks.
    T_____ F_____ Reference _____

23. It is not unusual to construct a floor that is exposed to especially severe conditions of traffic and abrasion in two layers.
    T_____ F_____ Reference _____

24. Polyethylene film used to cure concrete should consist of two sheets at least 4 mils in thickness and be black in color.
    T_____ F_____ Reference _____

25. Color can be imparted to concrete by paints, stains and pigments incorporated into the concrete when it is mixed.
    T_____ F_____ Reference _____

26. A concrete surface is ready for final finishing operations when all bleedwater has evaporated.
    T_____ F_____ Reference _____

27. Slab edging is required along all isolation and construction joints.
    T_____ F_____ Reference _____

III Completion

28. _____ produces a radius or rounded edge to the concrete that protects the concrete from _____or other _____.
    Reference _____

29. The dry shake method of coloring concrete consists of _____ cement, _____ and specially graded _____.
    Reference _____

30. Trowels are made of heat-treated_____ steel or stainless steel and are _____ to _____ inches long and _____ to _____ inches wide.
    Reference _____

31. Curing methods that supply moisture include _____ , _____ and other moisture-retaining _____ .
    Reference _____

32. A dry shake or dust coat can be applied to a one-course slab to give it a high resistance to _____ and _____ . Application of a dry shake is spread on the floated slab _____ the bleed water has _____ .
    Reference _____

33. Materials that can be used for curing concrete include_____ , _____ compounds, and various _____ and _____.
    Reference _____

34. A grooving tool is usually made of _____ , _____ or _____ , and is usually _____ inches long with ends _____ slightly to facilitate its use.
    Reference _____

35. Aggregate for heavy-duty floors must be_____ and _____, consisting of _____, _____or similar natural rock particles, or a manufactured product.
    Reference _____

36. When using sealing compounds to cure concrete, the compounds should be of a consistency suitable for _____, should be relatively _____, should adhere to a vertical or horizontal _____ concrete surface, and should not react _____ with the concrete.
    Reference _____

37. Moist curing after steaming improves _____ and _____ ,
    and should be utilized if possible. The greatest advantage of steaming occurs during the _____ and soon reaches a point of diminishing return.
    Reference _____

CHAPTER 18
THE REINFORCEMENT

Objectives: To give a general overview of the kinds of reinforcing used, how it is fabricated, and its placing, handling and inspection. Also, to provide a brief look at fiberglass and stainless steel reinforcement.

Lesson Notes: Perhaps the most important aspect of placement of reinforcement is that it must be installed exactly per the approved plans and engineering details. Substitution of sizes, cutting, bending, splicing and relocation should never be permitted unless approved by the engineer and the building official.

Key Points:

- Why is reinforcement used in concrete?
- At what locations in a beam is reinforcement usually placed?
- Of what configuration are stirrups, and how are they placed?
- What are the nominal diameters of #4, #6 and #9 bars?
- What are the equivalent metric numbers for #4, #6 and #9 bars?
- What does the grade of steel indicate?
- What is the specified yield strength of a Grade 60 bar?
- Define *yield point* and *ultimate tensile strength*.
- Review Figure 18-4, and identify what each of the marks on a reinforcing bar indicate.
- Describe what each of the numbers and letters mean in WWR 6 x 12-W1 6 x W26.
- What is the substitute letter for deformed wire?
- What is a bar mat?
- What is a sand plate?
- What are the three classes of metal bar supports?
- Define *placing drawings*.
- What is contained in placing drawings?
- What is a bar list?
- Of what does a reinforcing schedule consist?
- How is steel bent?
- Review the rebar placing tolerances in Tables 18.7 and 18.8.
- What are bundled bars?
- What information should the tag on bundled bars contain?
- What is a manifest?
- What is contained in a manifest?
- How should reinforcing bars be stored at the job site?
- Of the following list, which item(s) is acceptable on reinforcing? Oil, grease, light rust, paint, mill scale.
- When may reinforcing be heated for bending?
- After heating, how should a bar be cooled?
- What should be inspected and verified on each shipment of reinforcing?
- When is welding of crossing bars allowed?
- When is field bending of partially embedded reinforcing acceptable?
- What is mill scale?

- What is the maximum amount of rust that is acceptable on steel?
- How are dowels held in place?
- Name the three general types of bar splices.
- How are splices in adjacent bars done?
- What criteria are followed when using a mechanical splice?
- What are the two types of welded splices?
- Describe a potential problem of welded splices.
- What is meant by the term *dobies*?
- What is the purpose of tying reinforcing?
- Do all intersections have to be tied?
- Why is placing the steel within code tolerances important?
- What are the usual tolerances for stirrups and column ties?
- What is the purpose of providing concrete cover over reinforcing?
- How is welded wire reinforcement lapped?
- Specify the correct and incorrect placement procedures for welded wire reinforcement.
- Which fiber reinforcement is the one most commonly used?
- Are there any concerns with using galvanized reinforcing?
- Describe the special precautions necessary when using epoxy-coated steel.

CHAPTER 18—QUIZZES

I Multiple Choice

1. Excessive rusting of the reinforcement weakens the steel and also causes _____ , which may result in spalling and cracking.

   a. small voids
   b. an expansion in volume
   c. a loss of water proofing
   d. a loss of durability
   e. all of the above

   Response _____ Reference _____

2. Which of the following does not interfere with steel bonding to concrete?

   a. paint
   b. grease
   c. mill scale
   d. oil
   e. light rust

   Response _____ Reference _____

3. Epoxy-coated reinforcement should be checked for _____ .

   a. proper mechanical splices
   b. rust
   c. smoothness
   d. damaged coating
   e. all of the above

   Response _____ Reference _____

4. A #5 bar has an approximate diameter of _____ inch.

   a. $^{5}/_{8}$
   b. $^{5}/_{16}$
   c. $^{1}/_{2}$
   d. $^{3}/_{4}$
   e. none of the above

   Response _____ Reference _____

5. An advantage of using WWR is _____.

   a. lighter weight
   b. ease of use in columns and beams
   c. increased tensile strength
   d. speed and ease of installation
   e. ease of use in transverse structures

   Response _____ Reference _____

6. Welded splices can be either lap welds or _____ welds.
   a. proprietary
   b. mechanical
   c. tied
   d. hooked
   e. butt

   Response _____ Reference _____

7. To resist movement or displacement, reinforcing bars must be _____ .
   a. supported
   b. welded together
   c. tied together
   d. hooked
   e. any of the above

   Response _____ Reference _____

8. Field bending is apt to result in _____ .
   a. loss of ductility
   b. loss in compressive strength
   c. loss of bond
   d. increased lap slices
   e. expansion

   Response _____ Reference _____

9. Carbon-steel reinforcing bars are available in Grades _____ .
   a. 35, 40 and 50
   b. 40, 50 and 60
   c. 40, 60 and 75
   d. 40, 60 and 80
   e. 60, 75 and 90

   Response _____ Reference _____

10. In addition to the two main ribs, a reinforcing bar may have a third rib. This indicates _____ .
    a. type of steel
    b. Grade 60
    c. Grade 75
    d. rail steel
    e. low-alloy steel

    Response _____ Reference _____

11. Factory-made wire bar supports may be made of _____.
    a. plain wire
    b. galvanized wire
    c. stainless steel wire
    d. all of the above

    Response _____ Reference _____

12. A reinforcing bar shipment from a fabricator will be accompanied by a list known as a _____ .
    a. manifest
    b. invoice
    c. trip ticket
    d. delivery ticket
    e. none of the above

    Response _____ Reference _____

13. The most widely used reinforcing bars are_____.
    a. axle steel
    b. billet steel
    c. carbon steel
    d. low-alloy steel
    e. rail steel

    Response _____ Reference _____

14. A #22 metric reinforcing bar is the same size as a _____ inch-pound reinforcing bar.
    a. #5
    b. #6
    c. #7
    d. #8
    e. none of the above

    Response _____ Reference _____

15. The equivalent metric grade mark for the inch-pound grade mark 75 is _____.
    a. 3
    b. 4
    c. 5
    d. 42
    e. 52

    Response _____ Reference _____

16. According to the placing drawing (Figure 18-15) of the *Concrete Manual*, the required number of stirrups at each end of grade beam GB1 is indicated as _____ .

    a. 3@5 inch
    b. 3@6 inch
    c. 4@5 inch
    d. 4@6 inch
    e. none of the above

    Response _____ Reference _____

17. According to the placing drawing (Figure 18-15) of the *Concrete Manual*, the required reinforcing (each way) for footing F2 is indicated as _____.

    a. 12#19
    b. 24#19
    c. 10#22
    d. 20#22
    e. 16#22

    Response _____ Reference _____

18. According to the placing drawing (Figure 18-15) of the *Concrete Manual*, the footing dowels for column D1 may extend _____ vertically into the column and be
    within acceptable tolerance (+/- 2 inch).

    a. 2' 0"
    b. 2' 1"
    c. 2' 6"
    d. 2' 8"
    e. 2' 10"

    Response _____ Reference _____

19. Suggested minimum spacing of supports for D9 WWR @14-inch wire spacing used in slab-on-ground applications is _____.

    a. 2 to 3 ft
    b. 3 to 4 ft
    c. 4 to 6 ft
    d. 6 to 8 ft
    e. none of the above

    Response _____ Reference _____

20. If a mill test report is not available, welding of #6 carbon steel rebars is permitted if the bars are preheated to _____ °F.

    a. 100
    b. 200
    c. 300
    d. 400
    e. 500

    Response _____ Reference _____

21. If a mill test report is not available, welding of #6 low-alloy steel rebars is permitted if the bars are preheated to _____ °F.

    a. 50
    b. 200
    c. 300
    d. 500
    e. no preheat required

    Response _____ Reference _____

22. If the design drawings for an 8-inch concrete tilt-up panel indicate a $1^1/_2$-inch cover to the vertical rebars, the minimum acceptable measured cover is _____ inch.

    a. $^3/_4$
    b. 1
    c. $1^1/_8$
    d. $1^1/_4$
    e. none of the above

    Response _____ Reference _____

23. If the design drawings for a 24-inch deep spandrel beam at the perimeter of an elevated slab indicate a clear cover of $1^1/_2$ inches to the bottom reinforcing bars, the minimum acceptable measured cover is _____ inch(es).

    a. 1
    b. $1^1/_8$
    c. $1^1/_4$
    d. $1^3/_8$
    e. none of the above

    Response _____ Reference _____

24. If the design drawings for a structural slab indicate that the bottom bars of the end span are to be located 3 feet from the center of the interior column support, the minimum acceptable measured distance is _____ .

    a. 2 feet, 8 inches
    b. 2 feet, 9 inches
    c. 2 feet, 10 inches
    d. 2 feet, 11 inches
    e. 3 feet, 0 inches

    Response _____ Reference _____

25. The equivalent metric designation for inch-pound WWR sheet 6 x 6 - W4 x W4 is _____.

    a. 102 x 102 - MW9 x MW9
    b. 102 x 102 - MW26 x MW26
    c. 152 x 152 - MW9 x MW9
    d. 152 x 152 - MW19 x MW19
    e. 152 x 152 - MW26 x MW26

    Response _____ Reference _____

II True/False

26. Bar mats are similar to WWR except that they are made with reinforcing bars.

    T_____ F_____ Reference _____

27. All bends are made with the steel at normal room temperature except in cold weather, in which case hot bending is permitted.

    T_____ F_____ Reference _____

28. Tying the steel is done after it has been placed and spaced properly.

    T_____ F_____ Reference _____

29. The primary purpose of concrete cover for reinforcing steel is to protect the steel from weathering.

    T_____ F_____ Reference _____

30. Heavy welded wire reinforcement comes in flat sheets and is used primarily as structural reinforcement.

    T_____ F_____ Reference _____

31. A light coating of rust can decrease bond as well as cause spalling and cracking.

    T_____ F_____ Reference _____

32. Welded wire reinforcement is identified by denoting smooth wire with the letter “F,” followed by a number indicating the cross-sectional area in hundredths of a square inch.

    T_____ F_____ Reference _____

33. Class 1 metal supports are plastic protected steel wire bar supports intended for use in moderate to severe exposure of the concrete surface.

    T_____ F_____ Reference _____

34. Bar supports for epoxy-coated reinforcing bars should be coated with a dielectric material such as plastic.

    T_____ F_____ Reference _____

35. A standard hook can be a 180-degree bend plus $4_{db,}$ but not less than a $2^{1}/_{2}$-inch extension at the free end of the bar.

    T_____ F_____ Reference _____

36. It is sometimes advantageous to assemble the steel into *cages* in which the bars, stirrups and other elements can be tied together at a convenient assembly location.

    T_____ F_____ Reference _____

37. If a reinforcing bar appears to have rusted excessively, a sample should be cleaned and weighed to determine compliance with the specified weight.

    T_____ F_____ Reference _____

38. Reinforcing bars are cold rolled into bar size and deformations.

    T_____ F_____ Reference _____

39. USA-produced metric reinforcing bars are approximations of the inch-pound bar diameter in meters (m).

    T_____ F_____ Reference _____

40. If the structural drawings indicate a #9 reinforcing bar, and the iron worker is placing a bar marked 19, the inspector should notify the contractor of the incorrect bar size.

    T_____ F_____ Reference _____

41. If the structural drawings indicate a Grade 75, #14 reinforcing bar, and the iron worker is placing a bar marked 43 with a grade mark 5, the inspector should notify the contractor of the incorrect bar.

    T_____ F_____ Reference _____

42. USA-produced reinforcing bars furnished on the construction project most likely will be soft metric.

    T_____ F_____ Reference _____

43. Epoxy coating of reinforcement is an acceptable surface condition of reinforcement.

    T_____ F_____ Reference _____

44. FRP rebar significantly improves the longevity of concrete structures where corrosion is a major factor.

    T_____ F_____ Reference _____

45. Flat sheet *width* dimension for WWR includes end overhangs.

    T_____ F_____ Reference _____

46. Flat sheet *length* dimension for WWR includes end overhangs.

    T_____ F_____ Reference _____

III Completion

47. The minimum yield designation for Grade 60 reinforcing can be marked on the bar by either _____ longitudinal line or the number _____. Grade 75 can be marked by either _____ longitudinal lines or the number _____.

    Reference _____

48. When wire fabric is supplied to the job in rolls, it is rolled out, then draped from a position near the top of the slab over the _____ to the bottom of the slab at _____ , keeping the required _____ at each location.

    Reference _____

49. Epoxy-coated reinforcing was initially developed for use in highway bridge decks where concrete is subjected to severe exposures from _____ , _____ and _____ .

    Reference _____

50. Steel should be stored on_____ or other _____ off the ground to protect it from _____ and _____ on the jobsite and in locations where it may be splattered with _____. Long storage periods will result in excessive _____ or contamination.

    Reference _____

51. A bar list is a bill of materials or a list of_____ covering a portion of the structure. Bars are classified as to _____ , _____ , and whether they are _____ or _____.

    Reference _____

52. Although accuracy is important, it is necessary to allow for slight inaccuracies in the _____ . These allowances are called _____ . The typical tolerance for a straight bar is plus or minus _____ inch.

    Reference _____

53. Reinforcing steel must be secured in place. Distances from subgrade and forms should be maintained by the use of_____ , _____ , _____ or other approved _____.

    Reference _____

54. Heating in order to bend reinforcing can only be done when approved by the _____ with the concurrence of the _____ . If heating is approved, bars should be heated _____ and air cooled _____.

    Reference _____

55. Reinforcement is used to control cracks in slabs caused by _____ and _____ of the concrete resulting from temperature _____. The reinforcement does not prevent _____ .

    Reference _____

56. Grades of reinforcing steel are specified by the _____ and must be indicated on the _____ and _____.

    Reference _____

CHAPTER 19
HOT AND COLD WEATHER CONCRETING

Objectives: To obtain an understanding of the requirements for placing concrete in hot and cold weather, as well as how to minimize the effects of—and how to control and protect concrete in—weather extremes.

Lesson Notes: It is best to delay placing concrete when weather extremes occur; however, if placement must proceed, a little extra effort can obtain good, durable concrete.

- What is considered hot weather for placing concrete?
- List the possible undesirable effects of hot weather on concrete.
- Does hot weather concreting affect strength?
- How much additional mixing water might be required for a temperature increase of 10ºF?
- Explain how shrinkage and cracking is aggravated during hot weather.
- Will hot weather affect concrete after it has hardened?
- Where does control of the temperature of fresh concrete begin?
- Describe the ways in which controlling the aggregate temperature can be a benefit.
- How is mixing water kept cool?
- May ice ever be used to cool fresh concrete?
- Which type of admixtures are used to best advantage during hot weather concreting?
- List the items that must be planned prior to placing and finishing concrete in hot weather.
- How do fog nozzles help protect fresh concrete from the effects of hot weather?
- What is the best curing during hot weather concreting?
- Review the summary of hot weather precautions given in Table 19.1 of the *Concrete Manual*.
- At what temperature does cold weather become a concern for placing concrete?
- How does cold weather affect the hydration process?
- How is strength affected by cold weather concreting?
- During what period of time should fresh concrete be protected from cold weather?
- List the indirect effects of cold weather on the durability of concrete.
- What is the best means of heating concrete when freezing temperatures are expected?
- How are aggregates heated?
- When should preparation for cold weather concreting begin?
- What should be the minimum temperatures for concrete placed in thick and thin members?
- When should calcium chloride not be used to accelerate setting time?
- Is air-entrainment desirable for cold weather concreting?
- What admixture is used to lower the freezing temperature of concrete?
- How would a frozen subgrade affect concrete?
- List the best means of providing heat in a protective enclosure.
- How long should minimum temperatures be maintained?
- Should forms be left in place during cold weather?

- Review the summary of cold weather precautions listed in Table 19.3 of the *Concrete Manual*.

CHAPTER 19—QUIZZES

I Multiple Choice

1. Which one of the following is not an effect of hot weather concreting?

   a. accelerated setting
   b. increased plastic shrinkage
   c. lower volume of mixing water
   d. rapid slump loss
   e. reduced strength

   Response _____ Reference _____

2. Considerations for cold weather concreting should begin when the temperature drops below _____ºF.

   a. 25
   b. 32
   c. 40
   d. 45
   e. 50

   Response _____ Reference _____

3. Concrete should never be placed _____.

   a. on unreinforced slabs
   b. on a frozen subgrade
   c. during hot weather over 95ºF
   d. during cold weather below 25ºF
   e. all of the above

   Response _____ Reference _____

4. Which one of the following should not be used to accelerate the curing for prestressed concrete in cold weather?

   a. air-entrainment
   b. calcium chloride
   c. water-reducing admixture
   d. steam
   e. curing compounds

   Response _____ Reference _____

5. An economical and effective way to minimize the effects of hot weather is to cool the _____.

   a. mixing water
   b. sand
   c. coarse aggregate
   d. cement
   e. subgrade

   Response _____ Reference _____

6. If the temperature of a 10 cu yd batch of fresh concrete (in transit from the batch plant to the job site) increases from 50ºF to 75ºF, an additional _____ gallons of water will be required to maintain the same slump. Water weighs 8.33 lb per gallon.

   a. 10
   b. 20
   c. 30
   d. 40
   e. none of the above

   Response _____ Reference _____

7. In the absence of special precautions, undesirable cold weather effects may include _____.

   a. slower setting
   b. slower strength gain
   c. permanent damage that is due to early freezing
   d. reduced durability
   e. all of the above

   Response _____ Reference _____

8. Which one of the following is an acceptable procedure to cool the concrete ingredients during hot weather concreting?

   a. sprinkle coarse aggregate stock piles
   b. substitute ice as part of the mix water
   c. inject liquid nitrogen into the truck mixer
   d. provide cold air jets in the aggregate batcher bins
   e. all of the above

   Response _____ Reference _____

II True/False

9. Concrete needs about 7 pounds more water for each 10ºF rise in temperature.

   T_____ F_____ Reference _____

10. When heating mixing water, the temperature of the water should exceed 175ºF.

    T_____ F_____ Reference _____

11. During hot weather concreting, plans must be made so that concrete can be received and placed as rapidly as possible. All equipment should be of adequate capacity, and a sufficient number of workers of all necessary trades should be on hand.

    T_____ F_____ Reference _____

12. High temperature can adversely affect the strength, durability and cracking of concrete, and its ultimate strength may not be as high as that of concrete placed at moderate temperatures.

    T_____ F_____ Reference _____

13. When curing concrete during hot weather, allowing the surface to dry between applications of water is not detrimental to the concrete except when Type III cement is used.

    T_____ F_____ Reference _____

14. If concrete mix proportions for a specified strength and slump were determined at a laboratory temperature of 50ºF, and the actual temperature at time of batching is 75ºF, additional water and cement will be required to maintain the specified strength and slump.

    T_____ F_____ Reference _____

15. To control the temperature of fresh concrete during hot weather concreting, use of a calcium chloride accelerator is an economical admixture to cool the ingredients.

    T_____ F_____ Reference _____

III Completion

16. Because uniform heating of aggregates is difficult, heating of the aggregates _____ be done when heating of the _____ alone would ensure delivery of the concrete at the required temperature.

    Reference _____

17. Results of observations have shown that concrete made and cured at temperatures between _____ ºF has a later higher strength than that of _____ cured concrete.

    Reference _____

18. Especially during hot weather, the amount of mixing of concrete should be the minimum that can achieve the necessary _____ and _____, and _____must be avoided.

    Reference _____

19. Inadequate precautions during hot weather can have an appreciably _____
effect on durability, the resistance to freezing and thawing cycles, and a _____ resistance to attach by _____ solutions.
Reference _____

20. The indirect effects of low temperatures include cracking of dehydrated areas caused by a lack of_____ of the surface from heaters and freezing of corners and edges of green concrete that has _____ but is still saturated with water and has _____.
Reference _____

CHAPTER 20
PRECAST AND PRESTRESSED CONCRETE

Objectives: To obtain an understanding of the pretensioning and post-tensioning methods of prestressing concrete, including the manufacture and production of precast and prestressed concrete products. Also discussed will be the handling and erection of pretensioned prestressed concrete units. Field procedures for post-tensioned slab construction, using the unbonded single-strand tendons, is also addressed.

Lesson Notes: For more details on the installation of unbonded post-tensioned tendons the reader is referred to the *Field Procedure Manual for Unbonded Single Strand Tendons.* Also, the *Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products* is suggested for an in-depth treatise on the manufacture and production of precast and prestressed concrete products. Refer to the resource references section at the back of the *Concrete Manual* for the relevant addresses.

Key Points:

- Define *precast concrete*.
- List the advantages of prestressed concrete when compared with conventional concrete.
- What is the difference between load-bearing and nonload-bearing members?
- Explain the reason for using shop drawings.
- Who should review shop drawings?
- Describe all the items that shop drawings should contain.
- What concerns are associated with form oils for precast concrete?
- How do extruding machines work?
- List the items to be checked by the inspector prior to placing concrete for precast members.
- What is the most frequently used method of curing precast elements?
- What is prestressed concrete?
- Compare and contrast the pretensioning and post-tensioning methods of prestressing.
- Which prestressing steel is the most widely used?
- What is the most commonly used grade of prestressing steel?
- Define *elastic modulus*.
- What is the average elastic modulus of prestressing steel?
- Describe the use of bulkheads in casting beds.
- How is prestressing steel elongated?
- How is the amount of elongation determined?
- What may be a source of error in measuring jacking forces?
- What is detensioning?
- What is the difference between multiple- and single-strand detensioning?
- To minimize cracking, what is important in developing a detensioning pattern?
- What is the acceptable amount of broken wires or strands in prestressing steel?
- What is the first concern after a precast unit is placed in a structure?
- What is the most common size of unbonded single-strand tendons?

- Describe what a tendon consists of.
- What is the purpose of the rubber or plastic block used in post-tensioning work?
- How is the steel in an unbonded tendon system protected?
- What information do the installation drawings for unbonded tendons contain?
- Describe in detail how unbonded tendons are shipped, labeled and placed.
- What are the concerns when welding near unbonded tendons?
- What admixture(s) should not be used in concrete placed in an unbonded slab system?
- When is shoring removed after placing concrete?
- Give a brief description of the stressing operation.
- What are the distinct construction phases in a post-tensioning system?

CHAPTER 20—QUIZZES

I Multiple Choice

1. Which of the following must not be used in post-tensioned prestressed concrete?

   a. air-entrainment
   b. calcium chloride
   c. Type III cement
   d. graded aggregates
   e. all of the above

   Response _____ Reference _____

2. Sheathing of unbonded prestressing tendons must prevent _____ during concrete placement.

   a. spalling
   b. intrusion of cement paste
   c. fracturing of anchorages
   d. displacement of tendons
   e. stressing of tendons

   Response _____ Reference _____

3. Preassembled post-tensioning tendons are usually shipped to the job site in _____ foot diameter coils.

   a. 3
   b. 4
   c. 5
   d. 6
   e. 7

   Response _____ Reference _____

4. For the pretensioning method of prestressing, there must not be a difference of more than _____ percent between stress computed from jacking pressure and stress computed from measurement of elongation.

   a. five
   b. six
   c. seven
   d. eight
   e. nine

   Response _____ Reference _____

5. The concrete cover between a tendon and an opening in a post-tensioned slab should not be less than _____ inches.

   a. 4
   b. 5
   c. 6
   d. 7
   e. 8

   Response _____ Reference _____

6. Prestressing force must be determined by _____.

   a. visual observation of tendon stress
   b. measurement of tendon elongation
   c. observation of jacking force
   d. both a and b
   e. both b and c

   Response _____ Reference _____

7. Sheathing of unbonded tendons in prestressed concrete must _____.

   a. be within 2 inches of each end
   b. be within 12 inches of each end
   c. not be allowed
   d. be with duct tape if within 12 inches of an end
   e. be over the entire length

   Response _____ Reference _____

8. Any difference between tendon elongation and jacking force on a calibrated gage must not exceed _____ percent for post-tensioned construction.

   a. two
   b. four
   c. five
   d. seven
   e. ten

   Response _____ Reference _____

9. Unbonded prestressing tendons must be coated with _____ .

   a. light oxide
   b. cement paste
   c. material to ensure corrosion protection
   d. paint
   e. galvanizing

   Response _____ Reference _____

10. Which one of the following is not considered to be a precast structural unit?
    a. mullion
    b. box unit
    c. stemmed unit
    d. girder
    e. joist

    Response _____ Reference _____

11. The most common method of curing in precasting plants is _____.
    a. mechanical
    b. high-temperature
    c. chemical
    d. moist
    e. all of the above

    Response _____ Reference _____

12. Immediately after placement of precast units in a structure, _____ must be accomplished.
    a. grouting
    b. temporary bracing
    c. final welding
    d. permanent bracing
    e. none of the above

    Response _____ Reference _____

13. Type _____ cement is most commonly used for precast prestressed concrete work.
    a. II
    b. III
    c. IV
    d. V
    e. none of the above

    Response _____ Reference _____

14. Construction details for post-tensioning work prepared by the post-tensioning fabricator are referred to as _____ .
    a. installation drawings
    b. placing drawings
    c. shop drawings
    d. structural drawings
    e. none of the above

    Response _____ Reference _____

15. For the installation drawing shown on page 449 of the *Concrete Manual*, indicated strand stressing number (43) consists of _____ strands.

    a. one
    b. two
    c. three
    d. four
    e. five

    Response _____ Reference _____

16. For high-temperature curing of precast-prestressed units, the maximum curing temperature is limited to _____ ^{o}F.

    a. 100
    b. 125
    c. 150
    d. 175
    e. 200

    Response _____ Reference _____

II True/False

17. Differences in the modulus of elasticity of different production lots of steel is a source of error in measuring jacking forces.

    T_____ F_____ Reference _____

18. Prestressed concrete requires less reinforcing steel and concrete to produce units with strength equal to conventionally reinforced concrete.

    T_____ F_____ Reference _____

19. At least two certified test reports should be furnished for each 20-ton production of each size of prestressing steel.

    T_____ F_____ Reference _____

20. In general, most prestressing strands are tensioned to about 70 percent of ultimate strength.

    T_____ F_____ Reference _____

21. Conduits and other utilities cannot be accommodated in precast concrete.

    T_____ F_____ Reference _____

22. Positioning of prestressing strands is not critical in precast units.

    T_____ F_____ Reference _____

23. Unbonded single-strand tendons used in post-tensioned slabs usually consist of $^{1}/_{2}$-inch, or 0.6-diameter seven-wire strand.

    T_____ F_____ Reference _____

24. Batching of concrete mix ingredients at precasting plants is by weight, although water and liquid admixtures can be batched by volume.

    T_____ F_____ Reference _____

25. Casting bed bulkheads are usually set with a space of 6 inches between them to facilitate subsequent operations.

    T_____ F_____ Reference _____

26. Precast prestressed units can be stored on the ground and stacked after curing, provided the surface is level.

    T_____ F_____ Reference _____

27. In long precast prestressing beds it is sometimes the practice to oil the tendons before they are placed in the forms.

    T_____ F_____ Reference _____

28. At strand detensioning, the tension in the prestressing strands is transferred to the concrete, placing the concrete under compression.

    T_____ F_____ Reference _____

29. Long casting beds are not practical for producing multiple units of identical cross section and strand pattern.

    T_____ F_____ Reference _____

30. It is essential that the shoring for post-tensioned slabs be left in place until the stressing is completed.

    T_____ F_____ Reference _____

31. The greatest majority of forms for precast concrete are made of steel.

    T_____ F_____ Reference _____

32. The most widely used prestressing steel in building construction is the $^{1}/_{2}$-inch 270K stress-relieved-seven-wire strand.

    T_____ F_____ Reference _____

33. A small amount of rust on the surface of prestressing steel is beneficial to bond.

    T_____ F_____ Reference _____

34. For the installation drawing shown on page 449 of the *Concrete Manual*, strand stressing number (19) consists of one strand with an indicated elongation of $7^{1}/_{4}$ inches.

    T_____ F_____ Reference _____

35. For the installation drawing shown on page 449 of the *Concrete Manual*, strand stressing number (34) is 36 feet in length.

    T_____ F_____ Reference _____

36. The precast industry almost exclusively uses the 4-inch by 8-inch cylinder for evaluation and acceptance of concrete.

    T_____ F_____ Reference _____

III Completion

37. When installing unbonded tendons, an inspector should check that the tendons are placed at the correct _____ and _____ elevations and that the profiles are _____ and correctly _____.

    Reference _____

38. In post-tensioned concrete, the tendons are placed _____ the reinforcing
    steel, electric conduit, and mechanical work.

    Reference _____

39. The shop drawings for precast concrete units are usually prepared by the _____ or the _____.

    Reference _____

40. Where space permits, on site precasting can be adopted for buildings where there are many_____ units.

    Reference _____

41. In any prestressing operation there is a small amount of slippage that develops as the _____ grip the _____ at the _____.

    Reference _____

42. Pretensioning is the method of prestressing in which the tendons are elongated _____ to the placement of _____, and post-tensioning is the method of prestressing in which the tendons are elongated _____ the placement of _____.

    Reference _____

43. Prestressing strand is available in low-relaxation and _____. Low-relaxation strand has a lower steel-relaxation _____ and a higher _____ strength.

    Reference _____

44. Most precast concrete units have lifting hardware_____ in the concrete when the unit is _____. This hardware usually consist of an_____ and an _____ element.

    Reference _____

45. Post-tensioned tendons have a grease applied to the strand, which acts as a _____ coating and a _____ between the strand and the _____.

    Reference _____

46. The modulus of elasticity of prestressing steel averages about _____ psi.
    This can vary as much as _____ percent between lots.

    Reference _____

CHAPTER 21
LIGHTWEIGHT AND HEAVYWEIGHT CONCRETE

Objectives: To give an introduction to the batching, mixing, handling, placing and finishing of lightweight and heavyweight concrete.

Lesson Notes: Lightweight and heavyweight concrete have many similarities to normal-weight concrete; however, each of these two classes of concrete has special requirements that must be followed if their intended purpose is to be met. Compare the aggregate grading requirements for lightweight concrete in Table 21.2 with those for normal weight concrete in Table 8.5.

Key Points:

- Name the two general types of lightweight concrete.
- What is the primary reason to use lightweight structural concrete?
- Name some of the advantages of structural lightweight concrete.
- List the natural and manufactured materials that are used as aggregates in lightweight concrete.
- Describe the properties of lightweight aggregates for structural concrete.
- Describe in detail the two processes for manufacturing lightweight structural aggregates.
- What is the maximum absorption rate variation in the rotary kiln process?
- Which ASTM Standard covers lightweight aggregates?
- Can the principles of normal-weight concrete proportioning be applied to lightweight concrete?
- Give a brief description of the process of vacuum treatment of lightweight aggregate.
- How might the variations in specific gravity of particles be affected by water?
- Which affects the quality of lightweight concrete: active or free moisture?
- How is volumetric batching of lightweight concrete accomplished?
- Describe the appearance of fresh lightweight concrete.
- What slump is best for lightweight concrete slabs and structural elements?
- How should lightweight concrete be mixed in a truck mixer?
- What does a change in the unit weight indicate?
- How is air content determined for lightweight concrete?
- What are the concerns regarding vibration of lightweight concrete?
- How is finishing of lightweight concrete different from that for normal-weight concrete?
- What is the density of lightweight insulating concrete?
- Which types of aggregates are used for lightweight insulating concrete?
- What is perlite?
- Give the water requirements for perlite and vermiculite.
- Describe the ways to mix insulating concrete at the site or in transit.
- What actions may cause insulating concrete to become denser?
- What is the most common use of lightweight insulating concrete?
- Briefly describe the methods of placing lightweight insulating concrete.
- Define *cellular concrete*.

- Describe the two methods for making mechanically foamed cellular concrete.
- Where is heavyweight concrete most frequently used?
- Name the principal aggregates used for heavyweight concrete.
- List the requirements for heavyweight concrete with regard to mixing, placing and vibration.
- What is the intrusion method of placing concrete?
- How is heavyweight concrete affected by temperature?

CHAPTER 21—QUIZZES

I Multiple Choice

1. Which of the following is not one of the principle aggregates used in heavyweight concrete?

   a. barite
   b. granite
   c. limonite
   d. magnetite
   e. iron

   Response _____ Reference _____

2. Screeding and bullfloating operations for lightweight concrete slabs must be kept to a minimum because of the tendency of the aggregate to _____ .

   a. segregate
   b. float to the surface
   c. absorb additional water
   d. sink to the bottom
   e. none of the above

   Response _____ Reference _____

3. In the kiln process of manufacturing lightweight aggregate, the material reaches a temperature of _____ ºF.

   a. 800 to 1000
   b. 1000 to 1200
   c. 1200 to 1600
   d. 1600 to 1800
   e. 1800

   Response _____ Reference _____

4. Lightweight structural concrete is usually defined as having a compressive strength in excess of _____ psi at 28 days.

   a. 1800
   b. 2000
   c. 2500
   d. 3000
   e. 325

   Response _____ Reference _____

5. Aggregate for lightweight insulating concrete includes _____.
   a. limonite
   b. barite
   c. magnetite
   d. perlite
   e. all of the above

   Response _____ Reference _____

II True/False

6. Manufactured aggregates for lightweight structural concrete do not include clay and slate.

   T_____ F_____ Reference _____

7. Except for absorption factors, the principles of normal-weight concrete proportioning apply to lightweight concrete.

   T_____ F_____ Reference _____

8. In heavyweight concrete, segregation concerns are the same as for normal-weight concrete because the specific gravity is about the same.

   T_____ F_____ Reference _____

9. Natural aggregates used in lightweight structural concrete are normally smooth and round in shape, except for coated manufactured aggregates.

   T_____ F_____ Reference _____

10. The appearance of fresh lightweight concrete is similar to that of normal-weight concrete.

    T_____ F_____ Reference _____

III Completion

11. In the sintering process of manufacturing aggregates for lightweight structural concrete, the raw material is _____ _____ , then mixed with a _____ amount of pulverized _____ or _____.

    Reference _____

12. Cellular concrete contains bubbles of _____ or _____ that are formed in the plastic mortar with the porous structure _____ after the material hardens.

    Reference _____

13. Lightweight structural concrete in walls and columns should be consolidated by using _____ . Special care must be used to prevent _____.

    Reference _____

14. In lightweight concrete, differences in the amount of _____ water result from slight variations in the _____ of the particles, time of exposure to _____ and different mixes.

    Reference _____

15. One method of making mechanically foamed cellular concrete is to mix the cement, aggregate, _____ and _____ together in a _____ or _____ mixer.

    Reference _____

CHAPTER 22
SPECIAL CONCRETING TECHNIQUES

Objectives: To obtain a general awareness of the special concreting techniques of tilt-up construction, slipforms, lift slabs, placing concrete under water, preplaced aggregate concrete, vacuum concrete and shotcrete. To give an introduction to polymer, fiber-reinforced, refractory, sulfur, cellular and self-consolidating concrete, and controlled low-strength backfill material. Also, to provide a review of the architectural applications of concrete.

Key Points:

- Define *tilt-up construction*.
- What is used as the casting platform for tilt-up construction?
- What is the best type of bond breaker for tilt-up construction?
- Give two methods for setting tilt-up panels.
- When can a tilt-up panel be raised?
- How can panels that need to be broken loose from the casting floor be moved without injury to the concrete?
- How are temporary braces attached?
- What is a slipform?
- What structures are well suited to slipform construction?
- In vertically moving slipforms, what is the purpose of having a slight draft?
- How close to being plumb should a vertical slipform be?
- How is true vertical movement provided for a slipform?
- How is a level condition maintained on a vertical slipform?
- What is the recommended slump of concrete used in vertical slipforms?
- Give the important considerations for vertical slipforms in the following areas: consolidation, placing delays and time constraints, finish, curing and rate of slip.
- For what are horizontal slipforms used?
- Describe the operation of a horizontal slipform.
- Briefly describe the lift slab technique.
- What is the usual jacking rate of a lift slab?
- What two items are of special importance to lift slabs?
- Can concrete be placed in running water?
- What admixtures are advantageous when placing concrete in water?
- What is the recommended slump for concrete placed under water?
- What methods of placement are used for concrete placed underwater?
- What is a tremie? How should a tremie be supported?
- How is the best end-control achieved?
- What criteria are followed for placing concrete with a tremie?
- What are the advantages and disadvantages of using a tremie?
- How is concrete placement with a pump accomplished?
- Why is it important to keep the discharge end of the pump submerged in the fresh concrete?
- Briefly describe the preplaced aggregate method.

- Which admixtures are used in preplaced aggregate concrete?
- Define *vacuum concrete*.
- How is the vacuum process accomplished?
- Name the benefits of the vacuum process.
- Define *shotcrete*.
- By what other name is shotcrete known?
- Describe the dry-mix and wet-mix methods of preparing shotcrete.
- Can shotcrete be used to repair concrete?
- What is rebound and can rebound be reused?
- How is shotcrete finished and cured?
- Describe how shotcrete is tested.
- How are the anchor bolts for a base plate set?
- What is the correct way to set an anchor bolt template?
- What is dry pack and how is it installed?
- Why add powdered aluminum to grout?
- Where might prebagged dry concrete be used?
- Define *polymer concrete*.
- What are the two types of polymer concrete?
- Describe the polymer-impregnated process.
- Compare and contrast the polymer-impregnated and the polymer-Portland cement processes.
- What is fiber-reinforced concrete?
- Name the types of fiber used in fiber-reinforced concrete.
- What are the common uses for each of these types of fiber?
- Where is refractory concrete used? Can refractory concrete be used for structural components?
- List the types of aggregates used in refractory concrete.
- When is concrete classified as architectural?
- Describe the four categories of architectural concrete.
- Why make a sample panel prior to placing architectural concrete?
- How is pigmented concrete mixed and placed?
- What special precautions must be taken when using pigmented concrete?
- How long should concrete age before paint is applied?
- How is Portland cement paint applied and cured?
- List the other types of paints that can be used on concrete.
- Describe the sand-bedding and aggregate transfer methods for preparing exposed aggregate.
- What does the term *rubbing* mean?
- Why and when is rubbing used?
- What is grout cleaning?
- How old should concrete be before attempting grout cleaning treatment?
- What effects do various aggregates have on white concrete?
- How do admixtures and pigments respond to white concrete?
- How are materials for white concrete batched?
- How might mixing time affect white concrete?
- How is finishing and curing of white concrete done?

- On what does roughness depend when sandblasting concrete?
- Will sandblasting remove surface lines?
- What type of aggregate is used in sandblasting?
- What is a bushhammer?
- How and for what is a bushhammer used?
- What is acid etching?
- How is etching done at a precast plant?
- How is the acid applied?
- What precautions must be taken when acid etching?
- How old should concrete be before grinding is done?
- How is sulphur concrete produced?
- Define autoclaved cellular concrete (ACC).
- What are the principal ingredients in ACC?
- How is ACC manufactured?
- Define *self-consolidating concrete* (SCC).
- Describe the primary use of SCC.
- Describe the J-ring test method for SCC.
- What is controlled low-strength material (CLSM)?
- What is the primary use of CLSM?

CHAPTER 22—QUIZZES

I Multiple Choice

1. A type of construction in which wall panels are cast in a horizontal position at the jobsite is called _____.

   a. slipform
   b. lift slab
   c. shotcrete
   d. tilt-up
   e. none of the above

   Response _____ Reference _____

2. Finishers on horizontal slipforms make repairs and contraction joints from _____.

   a. an outrigger
   b. grade
   c. openings in the center of the form
   d. an apron
   e. none of the above

   Response _____ Reference _____

3. When shotcreting, the nozzle should be held uniformly about _____ feet away from the surface.

   a. 6
   b. 5
   c. 4
   d. 3
   e. 2

   Response _____ Reference _____

4. Concrete surfaces are classified as _____.

   a. 1, 2, 3 and 4
   b. A, B, C and D
   c. integral, smooth, rough and treated
   d. unfinished, smooth, semirough and rough
   e. none of the above

   Response _____ Reference _____

5. When appearance is important, the recommended amount of white cement to produce white concrete is about _____ pounds per cubic yard.

   a. 500
   b. 560
   c. 620
   d. 640
   e. none of the above

   Response _____ Reference _____

6. When the pumping method is used to place concrete underwater, the end of the discharge line must be kept continuously _____.

   a. submerged in the fresh concrete
   b. charged with water
   c. ahead of the concrete
   d. at the bottom of the element
   e. none of the above

   Response _____ Reference _____

7. When sulphur concrete is being placed, the temperature of the concrete must be between _____ ºF.

   a. 150 and 200
   b. 175 and 225
   c. 275 and 300
   d. 350 and 425
   e. none of the above

   Response _____ Reference _____

8. To make an expansive grout, powdered aluminum can be added in the amount of _____ per sack of cement.

   a. $^1/_2$ pound
   b. 1 pound
   c. 1 cup
   d. 1 quart
   e. 1 teaspoon

   Response _____ Reference _____

9. Columns between tilt-up panels may be bonded to the panel concrete with _____ cast in the panel and extending into the column.

   a. tie bars
   b. jacks
   c. stirrups
   d. rigging
   e. none of the above

   Response _____ Reference _____

10. For preplaced aggregate concrete, if plaster sand is used in the cement-sand grout, the coarse aggregate can be as small as _____ inch.

    a. 1
    b. $^{7}/_{8}$
    c. $^{3}/_{4}$
    d. $^{1}/_{2}$
    e. $^{3}/_{8}$

    Response _____ Reference _____

11. Concrete should be at least _____ days old before grinding the surface.

    a. 7
    b. 14
    c. 21
    d. 28
    e. 35

    Response _____ Reference _____

12. Concrete mixes for vertical slipforms should have a slump between _____ inches.

    a. 4 and 6
    b. 3 and 6
    c. 4 and 8
    d. 2 and 6
    e. 2 and 4

    Response _____ Reference _____

13. Accurately setting anchor bolts for a base plate can be done by means of _____.

    a. reinforcing dowels
    b. set screws
    c. a template
    d. embedded nuts
    e. hooks or stirrups

    Response _____ Reference _____

14. The time and method of rubbing a concrete surface is stated in the _____.

    a. job specifications
    b. building code
    c. placing drawings
    d. rubbing manual
    e. curing schedule

    Response _____ Reference _____

15. Concrete conveyed through a hose in a stream of air and shot onto a surface at high velocity is known as _____.

    a. gunite
    b. vacuum concrete
    c. refractory concrete
    d. shotcrete
    e. polymer concrete

    Response _____ Reference _____

16. Sandblasting may cut a concrete surface as deep as _____ inch(es).

    a. $^1/_4$
    b. $^1/_2$
    c. $^3/_4$
    d. 1
    e. $1^1/_2$

    Response _____ Reference _____

17. Polymer-impregnated concrete can achieve compressive strengths of _____ psi.

    a. 3000 to 5000
    b. 3000 to 8000
    c. 5000 to 18,000
    d. 5000 to 25,000
    e. none of the above

    Response _____ Reference _____

18. If a pure white concrete is specified, white sand and coarse aggregate can be made by crushing white _____.

    a. quarzite
    b. limestone or quartz
    c. granite or mica
    d. marble or feldspar
    e. none of the above

    Response _____ Reference _____

19. In tilt-up construction, a _____ must first be placed on the casting floor.

    a. pickup point
    b. sack coat
    c. polymer
    d. epoxy resin
    e. bond breaker

    Response _____ Reference _____

20. Portland cement paint should have a creamy, thick consistency and should be applied with _____.

    a. a spray gun
    b. scrub brushes
    c. horse hair brushes
    d. sponges
    e. a wood float

    Response _____ Reference _____

21. Autoclaved cellular concrete is a porous material with a compressive strength between _____ .

    a. 150 and 300 psi
    b. 300 and 1000 psi
    c. 300 and 1500 psi
    d. 1000 and 3000 psi
    e. 1500 and 2500 psi

    Response _____ Reference _____

22. A self-compacting concrete that can flow into tight and inaccessible spaces is termed _____ .

    a. autoclaved aerated concrete
    b. controlled low-strength concrete
    c. polymer concrete
    d. self-consolidating concrete
    e. shotcrete

    Response _____ Reference _____

23. The slump diameter of a well-proportioned SCC mix is approximately _____ inches.

    a. 18
    b. 24
    c. 30
    d. 36
    e. none of the above

    Response _____ Reference _____

24. Controlled low-strength material is _____.

    a. a flowable fill material
    b. a porous building material
    c. self-leveling concrete
    d. very flowable concrete
    e. all of the above

    Response _____ Reference _____

25. The J-ring is a modified slump test used to measure unblocked flow of _____.
    a. autoclaved aerated concrete
    b. controlled low-strength concrete
    c. fiber-reinforced concrete
    d. self-consolidating concrete
    e. none of the above

    Response _____ Reference _____

26. A freshly mixed batch of pervious concrete has a _____.
    a. high cement-past content
    b. low void content
    c. high fine aggregate content
    d. very low slump
    e. all of the above

    Response _____ Reference _____

27. Ultra-high performance concrete provides compressive strengths up to about _____ psi.
    a. 5,000
    b. 10,000
    c. 15,000
    d. 20,000
    e. 29,000

    Response _____ Reference _____

28. Ultra-high performance concrete provides a material that is very _____ .
    a. durable
    b. ductile
    c. high strength
    d. impermeable
    e. all of the above

    Response _____ Reference _____

II True/False

29. Raising of a lift slab is accomplished by means of jacks mounted on top of the building columns.

    T_____ F_____ Reference _____

30. There are four basic shotcreting processes: dry-mix, wet-mix, pneumatic and injected.

    T_____ F_____ Reference _____

31. Grout for cleaning concrete walls should consist of one part cement with one and one-half to two parts fine sand that passes a 16 mesh screen.

    T_____ F_____ Reference _____

32. For steel-fiber-reinforced concrete, a five percent fiber content by volume of concrete is considered an upper limit.

    T_____ F_____ Reference _____

33. Strength test samples of shotcrete are made by filling a 6-inch by 12-inch cylinder directly from the nozzle.

    T_____ F_____ Reference _____

34. After proper curing, refractory concrete can be heated up immediately at a rapid rate.

    T_____ F_____ Reference _____

35. A bushhammer consists of a flat-faced tool that fits into a chipping gun.

    T_____ F_____ Reference _____

36. The vacuum process to produce vacuum concrete is accomplished by applying a vacuum to a fresh concrete surface to extract water and entrapped air.

    T_____ F_____ Reference _____

37. The sand-bedding technique to produce an exposed aggregate surface results in a depth of exposed aggregate up to 4 inches.

    T_____ F_____ Reference _____

38. Among the causes of color variation in white concrete are different brands of cement, different forming materials, different slumps and variations in curing.

    T_____ F_____ Reference _____

39. Vertical slipforms consist of an inside and outside form made of sheet steel. The outside form extends above the inside form about 6 inches.

    T_____ F_____ Reference _____

40. Sack rubbing is done to fill in or cover rock pockets or honeycombing defects.

    T_____ F_____ Reference _____

41. The slipform method of placing concrete requires a steady supply of available fresh concrete and placement made so that there is not more than an hour’s delay between lifts.

    T_____ F_____ Reference _____

42. The principal advantage of using a tremie to place concrete underwater is that dewatering of the foundation area is unnecessary.

    T_____ F_____ Reference _____

43. The size and location for pickup points on a tilt-up panel are determined by its size, weight, compressive strength and unit weight.

    T_____ F_____ Reference _____

44. Autoclaved cellular concrete is a nonstructural lightweight precast concrete building material.

    T_____ F_____ Reference _____

45. Autoclaved cellular concrete (ACC) can be used for structural applications if properly reinforced.

    T_____ F_____ Reference _____

46. Self-consolidating concrete is proportioned with about the same amount of mixing water as conventional concrete.

    T_____ F_____ Reference _____

47. Autoclaved cellular concrete is a special type of lightweight precast prestressed concrete building material.

    T_____ F_____ Reference _____

48. Controlled low-strength material requires some vibration for adequate consolidation.

    T_____ F_____ Reference _____

49. Individual ACC building elements are joined together by embedded dowels or ties.

    T_____ F_____ Reference _____

50. Self-consolidating concrete is proportioned to flow between and around reinforcement without vibration.

    T_____ F_____ Reference _____

51. Pervious concrete is a very high impermeable concrete that drains quickly.

    T_____ F_____ Reference _____

52. Pervious concrete resembles popcorn.

    T_____ F_____ Reference _____

53. The void structure of pervious concrete allows water to pass through and percolate into the ground.

    T_____ F_____ Reference _____

54. The addition of plastic fibers in a concrete mixture will require more water to maintain a specified slump.

    T_____ F_____ Reference _____

55. Self-consolidating concrete (SCC) tends to have higher plastic shrinkage cracking than conventional concrete.

    T_____ F_____ Reference _____

56. SCC is used in precasting plants because it produces a good surface finish.

    T_____ F_____ Reference _____

III Completion

57. Part of the wet-mix shotcrete process is that all ingredients, including _____, are thoroughly mixed together, placed in the delivery equipment _____ and conveyed by _____ to a nozzle.

    Reference _____

58. Glass-fiber-reinforced concrete is manufactured by a spray-up process that feeds a continuous strand of glass fiber into a compressed-air-powered _____, where it is cut into _____ and combined with a _____ and _____ slurry.

    Reference _____

59. Acid etching of a concrete surface can be done as soon as _____ days(s) after placing concrete, and all comparable areas should be etched at about the same _____ .

    Reference _____

60. Methods for placing concrete underwater include the use of _____, _____ and _____.

    Reference _____

61. After a base plate has been adjusted to the correct position, the space underneath is filled with _____ or _____ .

    Reference _____

62. When using pigments to color concrete, only pure metallic _____ should be used, in an amount determined by _____ .

    Reference _____

63. When repairing old concrete with shotcrete, all old unsound material must be _____ , corroded steel must be _____, and reinforcing securely _____ or _____ in place.

    Reference _____

64. When acid is applied to a concrete surface, the acid reacts with the _____ and will also attack _____ and _____ aggregate.

    Reference _____

65. Compared to untreated concrete, polymer-impregnated concrete has strength values _____ times greater, improved resistance to _____ and _____ , increased resistance to _____ attack, improved _____ resistance and _____ water absorption.

    Reference _____

66. When using a bucket to place concrete underwater, the bucket should be lowered _____ while underwater and should not be opened until the bucket contacts _____ concrete.

    Reference _____

CHAPTER 23
WATERPROOFING AND DAMPPROOFING

Objectives: To introduce dampproofing and waterproofing of concrete and to introduce some of the available materials and methods used to achieve this.

Lesson Notes: There are many materials and methods available for dampproofing and waterproofing of concrete. Care must be taken to follow all the manufacturer's directions explicitly to obtain an acceptable and lasting seal. There are also many new products not mentioned in the text that are effective in the repair of leaks in existing structures.

Key Points:

- Describe the two ways that water passes through concrete.
- What can contribute to the problem of maintaining a water-tight structure?
- Review permeability in Chapter 5 and waterproofing in Chapter 9.
- Of what materials do surface treatments consist?
- Give one effective method of providing protection of porous concrete under low water pressure.
- Describe some ways to provide drainage away from concrete walls.
- What are the three primary requirements for waterproofing or dampproofing concrete?
- List the types of materials used to waterproof concrete.
- Where is waterproofing required?
- List the concerns associated with the installation of a waterproofing membrane.
- Of what does an elastomeric membrane consist?
- How is elastic membrane applied and what care must be taken during installation?
- How does preformed sheet elastomeric membrane differ?
- How are single-component liquids applied?
- What is the minimum number of plies when using a bituminous membrane for waterproofing?
- Describe the conditions for application of a bituminous membrane system.
- When using plaster to waterproof concrete, how is it applied?
- How is sheet lead used to waterproof concrete?
- When is dampproofing appropriate?
- What is the difference between dampproofing and waterproofing?
- Can treatments for dampproofing be substituted for waterproofing? Is the reverse also true?
- Give a detailed description of how to seal a leaking structure subject to a hydrostatic head.
- Is Type III cement a good material for this purpose?

CHAPTER 23—QUIZZES

I Multiple Choice

1. When a waterproofing system fails, the problem can usually be traced to _____ .
   a. improper construction
   b. material breakdown
   c. faulty materials
   d. temperature fluctuations
   e. all of the above

   Response _____ Reference _____

2. Quick-setting cement can be made by mixing Type III cement with _____.
   a. perlite
   b. aluminous cement
   c. calcium chloride
   d. magnesium sulfate
   e. none of the above

   Response _____ Reference _____

3. Walls in basements should have surface water drain by sloping the ground away from the structure about $^{1}/_{2}$ inch in _____ feet.
   a. 5
   b. 10
   c. 15
   d. 20
   e. 25

   Response _____ Reference _____

4. To ensure watertightness of concrete, it should be wet cured for at least _____ days.
   a. 3
   b. 6
   c. 7
   d. 14
   e. 28

   Response _____ Reference _____

5. Modified polyurethanes that are applied directly to the concrete from a can and spread with a notched squeegee are known as _____ .

   a. sheet membrane
   b. bituminous membrane
   c. elastomeric membrane
   d. single-component liquid
   e. none of the above

   Response _____ Reference _____

II True/False

6. Waterproofing materials cannot be used to dampproof a structure.

   T_____ F_____ Reference _____

7. Plaster used to waterproof a structure is applied either by hand or machine in three coats, each about $^{3}/_{8}$ inch thick.

   T_____ F_____ Reference _____

8. A waterproof membrane should be protected as soon as it has been installed, and if the membrane is punctured it can be repaired by applying a patch of the membrane material.

   T_____ F_____ Reference _____

9. Outdoor pools are sealed with a membrane of sheet lead that is placed prior to placing concrete.

   T_____ F_____ Reference _____

10. There are usually two plies of bituminous membrane applied to an exterior vertical surface.

    T_____ F_____ Reference _____

III Completion

11. Manufacturers of bituminous membranes usually specify that, prior to application, the concrete is _____ , _____and _____. Also, all surface voids must be _____ with _____ and all fins and irregularities _____.

    Reference _____

12. Leaks can be repaired by removing _____ concrete and _____, and cracks should be _____ . A good proprietary material is then applied, starting from the_____ and working to the _____ point.

    Reference _____

13. Bituminous coatings consist of _____or _____ layers of bitumen, mopped on either _____ or _____. Cold-applied bituminous coatings can be reinforced with _____,_____ or other inert fibers.
    Reference _____

14. Waterproofing is required below _____ where groundwater is present against _____ and _____ , and above grade wherever protection is required against the _____ .
    Reference _____

15. To ensure watertight impermeable concrete, aggregates should be _____ and of _____ , and sand particles should be _____ .
    Reference _____

CHAPTER 24
INTRODUCTION TO INSPECTION

Objectives: To give an overview of the responsibilities and authority of building inspectors, special inspectors and quality control inspectors.

Lesson Notes: The job of the inspector is probably the most difficult of all of the members of the construction team. He or she must understand and apply all of the various tests, procedures, code requirements and specifications related to each individual project. He or she must know not only the exact wording of each of these but the intent as well, insofar as each project presents its own unique problems and conditions.

Key Points:

- Why is the team concept important in concrete construction?
- List each of the team players and their roles in providing quality concrete construction.
- Define *inspection*.
- Who might the inspector represent?
- Why is it not recommended to award a contract for inspection services to the lowest bidder?
- What can be the advantages to contractors who provide their own inspection staff?
- Who should employ the testing or inspection staff?
- List the qualities of a good inspector.
- To whom should the inspector give suggestions and instructions?
- How should the supervisor support the inspector?
- When a permit is required, who is the primary inspector?
- Describe the responsibilities of a special inspector.
- Is the building code the only document with which the inspector must be familiar?
- List the primary documents that should guide the inspector.
- What is the first duty of an inspector when assigned a project?
- List the duties of the inspector.
- What equipment does a testing agency usually provide on the jobsite?
- Which materials are usually tested at the manufacturer?
- What should accompany approved materials?
- When can rejected materials be used on a site?
- When are retests of rejected materials appropriate?
- How should the inspector be involved in job safety?
- What are the inspection tasks for batch plant inspection?
- Describe some methods for testing the moisture content of aggregates.
- What does the inspector check when inspecting reinforcing steel?
- When can alternate materials be used on a project?

CHAPTER 24—QUIZZES

I Multiple Choice

1. When special inspection is required, the special inspector should be in the employ of the _____ .

   a. contractor
   b. subcontractor
   c. owner
   d. building official
   e. none of the above

   Response _____ Reference _____

2. When a permit is required, the inspector employed by the building official is the _____ inspector.

   a. primary
   b. secondary
   c. special
   d. additional
   e. none of the above

   Response _____ Reference _____

3. Safety and accident prevention on the job site are the responsibility of the _____.

   a. owner
   b. inspector
   c. architect
   d. engineer
   e. contractor

   Response _____ Reference _____

4. There are _____ primary sources of authority that guide the inspector.

   a. one
   b. two
   c. three
   d. four
   e. five

   Response _____ Reference _____

5. Job specifications usually permit the use of alternative materials, provided necessary test reports and other pertinent information is submitted for approval by the _____.

   a. building official
   b. engineer
   c. architect
   d. owner
   e. engineer and owner

   Response _____ Reference _____

6. At the time of use, cement should contain no lumps that cannot be broken by _____.

   a. a hammer
   b. crushing
   c. light pressure between the fingers
   d. the aggregate
   e. none of the above

   Response _____ Reference _____

7. When required, test specimens of reinforcing steel should be chosen at random from the lot. Samples should be at least _____ inches long.

   a. 12
   b. 18
   c. 20
   d. 24
   e. 30

   Response _____ Reference _____

8. Which of the following is not provided by the testing and/or inspection agency?

   a. slump cone
   b. on-site storage
   c. scoop or shovel
   d. cylinder molds
   e. air content meter

   Response _____ Reference _____

II True/False

9. Inspection is the review of a contractor’s work to make sure that specifications, drawings and codes are being followed.

   T_____ F_____ Reference _____

10. Cement is rarely furnished to a job site because practically all concrete comes from a commercial ready-mix manufacturer.

    T_____ F_____ Reference _____

11. A special inspector is required to be on site only while concrete is being placed.
    T_____ F_____ Reference _____

12. One of the first duties of an inspector is to become familiar with the job requirements that pertain to inspection.
    T_____ F_____ Reference _____

13. Admixtures, curing compounds, joint fillers and similar materials are usually accepted on the manufacturer's certification.
    T_____ F_____ Reference _____

14. Rejected materials should be disposed of, modified or regenerated.
    T_____ F_____ Reference _____

15. Each load of approved materials should be accompanied by a tag or card of identification issued by the testing laboratory.
    T_____ F_____ Reference _____

16. When the specifications require a particular material, substitution of a different material, even if of equal quality, is never allowed.
    T_____ F_____ Reference _____

17. The approval of materials is usually the responsibility of the on-site inspector.
    T_____ F_____ Reference _____

18. 4-inch by 8-inch cylinder molds are never permitted for final evaluation and acceptance of structural concrete.
    T_____ F_____ Reference _____

III Completion

19. Of the several methods for obtaining the moisture content of an aggregate, the most common method is to_____ the aggregate in and _____ or over a _____.
    Reference _____

20. Although cement is manufactured under close _____ and rarely fails to meet _____, wide fluctuations in the cement's _____ may still exist.
    Reference _____

21. To obtain approval of a material, supporting data should be supplied that contain the history and _____ record as well as typical _____, _____ or shop _____ , including those by an _____ testing laboratory.
    Reference _____

22. When an inspector is assigned a project, one of his or her first tasks is to become familiar with the _____ requirements and the _____.

    Reference _____

23. The inspector should give _____ and _____ relative to the acceptance or rejection of construction or materials to the contractor or producer, not the _____ .

    Reference _____

24. An inspector at a batch plant should check the aggregate and have all _____, _____ or other _____ removed.

    Reference _____

CHAPTER 25
INSPECTION OF CONCRETE CONSTRUCTION

Objectives: To build on the information provided in Chapter 24 by deepening the understanding of the duties and responsibilities of the inspector, from preliminary arrangements to the final product.

Lesson Notes: One of the most important aspects of an inspector's job is to keep accurate records and reports. When good records and reports are kept, problems and questions that arise afterward can be addressed with facts instead of speculation.

Key Points:

- List the factors that determine the amount and extent of inspection.
- After the preliminary inspections, what are the three stages of inspection?
- What does each of the stages of inspection include?
- What is the most common method of batching and mixing concrete?
- What items need to be inspected at the time of proportioning and mixing?
- List the duties of the plant inspector at the beginning of each day.
- At what point does an inspector take samples and perform field tests of the fresh concrete?
- What items are to be inspected at the batch plant during the concreting phase?
- List the types of inspection that should occur during mixing, delivery, handling and placing of concrete.
- What should be inspected during jointing and finishing?
- Why is the keeping of accurate records and reports necessary?
- When is a narrative report done?
- When an inspector is assigned numerous jobs, what items should his or her diary include?
- Define *special inspection*.
- Why are special inspectors needed?
- Describe the role of the special inspector with relation to the enforcement agency.
- List the types of work related to concrete that are required to have special inspection.
- Give the general areas of responsibility and the qualifications of the special inspector.
- Review the job task analysis given in Table 25.1. Describe how each of the tasks might impact a project.

CHAPTER 25—QUIZZES

I Multiple Choice

1. Which one of the following is not part of the first stage of inspection?

   a. steel grade and size
   b. soil compaction
   c. strength tests
   d. form stability
   e. adequate lighting

   Response _____ Reference _____

2. The general building code typically requires that the special inspector be employed by the _____ .

   a. building official
   b. owner
   c. contractor
   d. subcontractor
   e. none of the above

   Response _____ Reference _____

3. A key element in the approval of a fabricating plant is _____ by an approved quality control agency.

   a. independent inspection
   b. testing
   c. supervision
   d. sampling
   e. sampling and testing

   Response _____ Reference _____

4. A concrete inspection log should contain _____ .

   a. strength specimen results
   b. unusual placing delays
   c. the number of workers
   d. ready-mix drum rotations
   e. all of the above

   Response _____ Reference _____

5. Ready-mix trucks should be checked by the inspector to verify that _____.
   a. engines are operational
   b. mixing water pump is adequate
   c. drums and chutes are clean of concrete
   d. mixing blades are worn
   e. all of the above

   Response _____ Reference _____

6. A special inspector supplements inspections provided by the building official with _____ inspections to help ensure that construction complies with the code.
   a. partial
   b. periodic
   c. overtime
   d. continuous
   e. any of the above

   Response _____ Reference _____

7. Which one of the following is not part of the preliminary arrangements prior to actual inspections?
   a. approving aggregates
   b. checking forms for line and grade
   c. calibrating scales and batchers
   d. preparing mix designs
   e. rejecting unsuitable materials

   Response _____ Reference _____

8. Which one of the following is not part of inspection during the final stage of concreting?
   a. applying curing compound
   b. repairing rock pockets
   c. timely removal of forms
   d. installing construction joints
   e. filling tie rod holes

   Response _____ Reference _____

II True/False

9. The second stage of inspection includes verifying the size, location and grade of the reinforcing steel.

   T_____ F_____ Reference _____

10. Areas of inspection of prestressed concrete include size and grade of tendons, placing of tendons, concrete placement and strand stressing.

    T_____ F_____ Reference _____

11. In building construction, the inspector is not called on to review nonstructural elements of a building, except at the request of the building official.

    T_____ F_____ Reference _____

12. A special inspector should notify the building official and engineer when discrepancies are not corrected.

    T_____ F_____ Reference _____

13. It is important for the inspector to maintain accurate and complete reports, but it is not necessary to include weather conditions and visitors to the job site.

    T_____ F_____ Reference _____

14. The general building code typically states that the fabricator’s facility and personnel must be verified by an approved inspection or quality control agency.

    T_____ F_____ Reference _____

15. Repairs of rock pockets should be made as early as possible because it is easier to work on green concrete.

    T_____ F_____ Reference _____

16. It is normal practice to sample concrete and perform tests at the point of placement after all water has been added and while concrete is being discharged.

    T_____ F_____ Reference _____

17. Special considerations for tilt-up construction include applying parting compound, watching for rebound and avoiding sudden jerks when lifting.

    T_____ F_____ Reference _____

18. The International Code Council offers a certification for reinforced concrete and prestressed concrete special inspector.

    T_____ F_____ Reference _____

19. Special inspection is always required for precast prestressed concrete manufactured in a precasting plant.

    T_____ F_____ Reference _____

20. Special inspection is always required for post-tensioned prestressed concrete construction.

    T_____ F_____ Reference _____

III Completion

21. The second stage of inspection of concrete occurs during the actual _____ , _____and _____of the concrete and extends through the _____ period.

    Reference _____

22. Although inspection may not be required, a _____ is usually necessary for concrete jobs, regardless of _____ .

    Reference _____

23. The special inspector is responsible for furnishing _____ to the building official and observing the work for compliance with approved _____ and _____ .

    Reference _____

24. In addition to verifying that applicants are technically competent, the building official should verify that applicants have related work experience and are aware of local code _____,_____ and _____.

    Reference _____

25. When inspecting prestressed concrete, the inspector should check the _____ of the stressing ram and the stressing _____ .

    Reference _____

26. Inspection of heavy-duty floors should include screeding, _____ and _____, troweling, wearing curse and special _____ .

    Reference _____

27. During concrete placement, the inspector should confirm that the _____ indicates the correct mixture, the concrete is _____ and the mix is used within the specified _____ .

    Reference _____

CHAPTER 26
QUALITY CONTROL

Objectives: To define quality control and its application to concrete construction.

Key Points:

- Define *quality control*.
- What are some of the primary areas in which quality control can be applied to construction?
- Who is responsible for quality control of concrete?
- What benefit does an owner obtain from quality control?
- What is needed for quality control to succeed?
- What is the difference between quality control and acceptance sampling?
- How have recent advances in technology aided statistical quality control (SQC)?
- What information is provided by statistical quality control?
- On what is statistical quality control based?
- What is a standard deviation?
- In what two ways is a standard deviation expressed?
- Define *coefficient of variation*.
- What leads to the greatest uniformity in the quality of concrete?
- In the area of concrete quality control, why are rigid numerical limits unrealistic for contractors and inspectors?
- What is the best index of concrete quality?
- What test is used to determine concrete strength?
- What accounts for the differences in strength of test cylinders?
- Do low strength results in some cylinders mean that construction quality is jeopardized?
- Is there an absolute minimum specified strength for concrete in building construction?
- What is a good index of the quality of concrete?
- Is the inspector expected to be able to make quality control computations?
- How can 28-day results be determined based on seven-day strength curves?
- What action might be required to correct deficiencies in concrete quality?
- In the production of concrete, what standard deviation value indicates good control? Fair control? Poor control?
- Why is it important for an inspector to understand the significance of statistical quality control?
- Does quality control result in added cost for the contractor?
- What section of the ACI 318 Standard states the requirements for concrete quality?

CHAPTER 26—QUIZZES

I Multiple Choice

1. If quality control is to succeed, there must be a rational system for analyzing the results of _____ .

   a. research
   b. tests
   c. samples
   d. SQC
   e. all of the above

   Response _____ Reference _____

2. An evaluation is possible to determine probable 28-day strengths from seven-day strength tests by using _____ .

   a. strength averaging
   b. known mix designs
   c. statistical analysis
   d. a control chart
   e. all of the above

   Response _____ Reference _____

3. In general, strength is a good index of concrete_____.

   a. quality
   b. durability
   c. workability
   d. tensile strain
   e. uniformity

   Response _____ Reference _____

4. _____ is a measure of variation derived mathematically from test results.

   a. Standard deviation
   b. Range
   c. Average
   d. Coefficient of variation
   e. none of the above

   Response _____ Reference _____

5. The total number of test values under consideration is called the _____.
   a. range
   b. mean
   c. population
   d. deviation
   e. numeric average

   Response _____ Reference _____

6. The calculated standard deviation (s = 353 psi) illustrated in Tables 26.3 and 26.4, for the column concrete with a specified strength of 4000 psi, represents_____.
   a. excellent quality control
   b. good quality control
   c. fair quality control
   d. poor quality control
   e. unacceptable quality

   Response _____ Reference _____

7. If a local ready-mix producer is proposing to use strength data with a standard deviation of 390 psi to bid on a project that requires concrete with a specified strength of 3500 psi, the required average strength used as the basis for selecting concrete mix proportions for the specified 3500 psi concrete should be _____ .
   a. 3500 psi
   b. 3900 psi
   c. 4000 psi
   d. 4100 psi
   e. 4700 psi

   Response _____ Reference _____

II True/False

8. Quality control is a system by which construction is controlled by scientific methods rather than chance.

   T_____ F_____ Reference _____

9. The inspector is not usually called upon to make computations on the job site; however, he or she should know and understand the significance of the statistical values used, and thus how well the job is being controlled.

   T_____ F_____ Reference _____

10. A slump test does not lend itself to the precision of measurement that a strength test does, and the results of the analysis ordinarily are not as meaningful.

    T_____ F_____ Reference _____

11. Quality control is a relatively new concept with regard to products manufactured at a permanently located factory or mill.

    T_____ F_____ Reference _____

12. To obtain accurate information, the results of a small number of tests should be presumed to be representative of the concrete produced.

    T_____ F_____ Reference _____

III Completion

13. Computer programs allow a continuing analysis that provides up-to-the-minute information on_____ , aggregate sieve_____ , _____ equivalents and any other test done on a _____ basis.

    Reference _____

14. Statistical methods provide the best basis for analyzing test results, determining potential _____ and _____ , and expressing _____ in the most useful form.

    Reference _____

15. When writing specifications, it is more realistic to base probabilities on statistical methods and permitting a certain _____ of strength tests _____ than specified _____ strength.

    Reference _____

16. Quality control _____ cost money, and the potential _____ are substantial.

    Reference _____

17. The primary function of compression tests is to serve as a measure of the _____ and _____ of concrete. The magnitude of variations in strength of concrete test specimens depends on how well the _____ , concrete _____ and tests are _____ .

    Reference _____

ANSWER KEYS

Chapter 1—Fundamentals of Concrete

1.	Sec.	1.1	b
2.	Sec.	1.8	c
3.	Sec.	1.3	b
4.	Sec.	1.2	a
5.	Sec.	1.1	e
6.	Sec.	1.5	T
7.	Sec.	1.8	F
8.	Sec.	1.7	F
9.	Sec.	1.1	T
10.	Sec.	1.2	T
11.	Sec.	1.3	green
12.	Sec.	1.6	durability
13.	Sec.	1.7	expansion, contraction, destructive solutions
14.	Sec.	1.1	gypsum
15.	Sec.	1.1	rotary kiln

Chapter 2—The Fresh Concrete

1.	Sec.	2.8	a
2.	Sec.	2.2	a
3.	Sec.	2.5	d
4.	Sec.	2.4	d
5.	Sec.	2.2	c
6.	Sec.	2.1	T
7.	Sec.	2.1	F
8.	Sec.	2.4	F
9.	Sec.	2.5	F
10.	Sec.	2.6	T
11.	Sec.	2.8	unit weight, bleeding
12.	Sec.	2.7	unit weight
13.	Sec.	2.1	consolidation, compaction, segregate
14.	Sec.	2.2	pavements, mass concrete, precast concrete
15.	Sec.	2.6	Bleeding

Chapter 3—The Strength of Concrete

1.	Sec.	3.3	d
2.	Sec.	3.11	b
3.	Sec.	3.13	e
4.	Sec.	3.11	b
5.	Sec.	3.15	d
6.	Sec.	3.11	b
7.	Sec.	3.7	b
8.	Sec.	3.11	a
9.	Table	3.1	d
10.	Sec.	3.2	a
11.	Fig.	3-2	d
12.	Sec.	3.4	c
13.	Sec.	3.5	c
14.	Sec.	3.7	b
15.	Sec.	3.11	b
16.	Fig.	3-8	a
17.	Sec.	3.13	d
18.	Sec.	3.14	b
19.	Table	3.5	c
20.	Sec.	3.16	b
21.	Sec.	3.2	c
22.	Sec.	3.15	b
23.	Sec.	3.5	T
24.	Sec.	3.9	F
25.	Sec.	3.13	T
26.	Sec.	3.17	T
27.	Sec.	3.2	T
28.	Sec.	3.15	T
29.	Sec.	3.17	F
30.	Sec.	3.11	T
31.	Sec.	3.15	F
32.	Sec.	3.14	slowed
33.	Sec.	3.4	Modulus, rupture, third, 6, 6
34.	Sec.	3.13	high-early-strength, accelerating, retention of, high-temperature, cements
35.	Sec.	3.11	2.25, one and one-half
36.	Sec.	3.9	swiss hammer, windsor probe

Chapter 4—The Durability of Concrete

1.	Sec.	4.10	e
2.	Sec.	4.3	c
3.	Sec.	4.1	d
4.	Sec.	4.5	b
5.	Sec.	4.2	b
6.	Sec.	4.4	c
7.	Sec.	4.3	d
8.	Sec.	4.11	F
9.	Sec.	4.3	T
10.	Sec.	4.11	T
11.	Sec.	4.1	T
12.	Sec.	4.3	F
13.	Sec.	4.12	F
14.	Sec.	4.2	T
15.	Sec.	4.8	Chamfers, fillets
16.	Sec.	4.6	nonbreaking, breaking, broken
17.	Sec.	4.9	hydraulic, lowering
18.	Sec.	4.3	resistant, barrier
19.	Sec.	4.1	material, concrete, exposure, loads, construction,
20.	Sec.	4.3	Ammonium, ammonia, hydrogen, acid

Chapter 5—Volume Changes and Other Properties

1.	Sec.	5.11	c
2.	Sec.	5.1	c
3.	Sec.	5.1	d
4.	Sec.	5.11	a
5.	Sec.	5.8	c
6.	Sec.	5.7	b
7.	Sec.	5.1	a
8.	Sec.	5.14	F
9.	Sec.	5.1	T
10.	Sec.	5.3	F
11.	Sec.	5.1	F
12.	Sec.	5.10	F
13.	Sec.	5.1	F
14.	Sec.	5.1	T
15.	Sec.	5.1	low, wind, air
16.	Sec.	5.4	variable effects, lowering
17.	Sec.	5.12	poor, dense
18.	Sec.	5.1	volume, bleed, tensile
19.	Sec.	5.8	measure of elasticity, E
20.	Sec.	5.2	expansion, contraction, wetting, reversible

Chapter 6—Cracks and Blemishes

1.	Sec.	6.2	d
2.	Sec.	6.5	b
3.	Sec.	6.6	a
4.	Sec.	6.16	d
5.	Sec.	6.26	a
6.	Sec.	6.11	e
7.	Sec.	6.20	c
8.	Sec.	6.4	c
9.	Sec.	6.7	T
10.	Sec.	6.10	F
11.	Sec.	6.13	T
12.	Sec.	6.15	T
13.	Sec.	6.23	F
14.	Sec.	6.28	F
15.	Sec.	6.22	T
16.	Sec.	6.1	F
17.	Sec.	6.3	reinforcing bars, items embedded, aggregate particles, cracks
18.	Sec.	6.5	openings, reinforcing
19.	Sec.	6.9	previously placed, slabs, walls
20.	Sec.	6.21	diagnose, cause, extent
21.	Sec.	6.8	designed properly, sections, reinforcing
22.	Sec.	6.18	peeling, scaling
23.	Sec.	6.27	adhesives, mortar sand, one, adhesive, three, sand
24.	Sec.	6.19	spalling, 1 inch, 6 inches

Chapter 7—Portland Cement

1.	Sec.	7.9	c
2.	Sec.	7.4	c
3.	Sec.	7.2	d
4.	Sec.	7.4	c
5.	Sec.	7.8	d
6	Sec	7.11	c
7	Sec	7.11	c
8.	Sec.	7.2	T
9.	Sec.	7.10	T
10.	Sec.	7.9	F
11.	Sec.	7.8	F
12.	Sec.	7.10	T
13.	Sec	7.2	F
14.	Sec	7.4	F
15.	Sec	7.11	T
16.	Sec	7.11	F
17.	Sec.	7.4	sulfate-resistant, soil, ground, sulfate
18.	Sec.	7.8	hydrates, accelerates
19.	Sec.	7.5	IS, IS-A, S, IP, P
20.	Sec.	7.2	gypsum, setting time
21.	Sec.	7.6	iron, I, tinted, colored
22.	Sec.	7.0	skin irritation, chemical burns
23.	Sec.	7.11	volcanic tuff, volcanic ash, pumicite, obsidian
24.	Sec.	7.11	Sulfate attack, alkali-silica, lowered heat

Chapter 8—Aggregates

1.	Sec.	8.6	c
2.	Sec.	8.3	b
3.	Sec.	8.7	e
4.	Sec.	8.3	d
5.	Sec.	8.3	a
6.	Sec.	8.4	c
7.	Sec.	8.7	b
8.	Sec.	8.4	a
9.	Sec.	8.3	T
10.	Sec.	8.0	T
11.	Sec.	8.5	F
12.	Sec.	8.10	F
13.	Sec.	8.2	T
14.	Sec.	8.4	F
15.	Sec.	8.6	F
16.	Sec.	8.3	T
17.	Sec.	8.3	T
18.	Sec.	8.7	three, two, fines, dust
19.	Sec.	8.9	blast furnace
20.	Sec.	8.1	three, igneous, sedimentary, metamorphic
21.	Sec.	8.3	two tenths, two or three, one and one-half
22.	Sec.	8.3	three, one-half, one
23.	Sec.	8.4	heavy media, jigging, impact crusher, elastic fraction-
24.	Sec.	8.4	clay, silt, revolving, log washer, screw washer
25.	Sec.	8.6	few, high, cone, layers, closely, vertical
26.	Sec.	8.3	rough, cement paste, smooth

Chapter 9—Water and Admixtures

1.	Sec.	9.2	b
2.	Sec.	9.2	e
3.	Sec.	9.3	d
4.	Sec.	9.2	b
5.	Sec.	9.1	a
6.	Sec.	9.2	T
7.	Sec.	9.2	F
8.	Sec.	9.2	T
9.	Sec.	9.1	F
10.	Sec.	9.2	F
11.	Sec.	9.2	T
12.	Sec.	9.2	intermixed, manufacturers
13.	Sec.	9.2	surfaces, natural, synthetic, polymers
14.	Sec.	9.2	absorption, capillary action
15.	Sec.	9.2	colorfast, chemically stable, setting time, strength
16.	Sec.	9.2	chemical, air-entraining

Chapter 10—Accessory Materials

1.	Sec.	10.1	a
2.	Sec.	10.3	e
3.	Sec.	10.6	a
4.	Sec.	10.1	e
5.	Sec.	10.3	c
6.	Sec.	10.4	F
7.	Sec.	10.5	F
8.	Sec.	10.7	T
9.	Sec.	10.2	embed, compressing
10.	Sec.	10.1	polyethylene, butyl, neoprene
11.	Sec.	10.3	resin, curing agent
12.	Sec.	10.2	sheet copper, rubbers, polyvinyl chloride

Chapter 11—Formwork

1.	Sec.	11.2	b
2.	Sec.	11.3	d
3.	Sec.	11.9	a
4.	Sec.	11.5	d
5.	Sec.	11.7	d
6.	Sec.	11.4	c
7.	Sec.	11.1	b
8.	Sec.	11.1	b
9.	Sec.	11.6	c
10.	Sec.	11.4	T
11.	Sec.	11.3	T
12.	Sec.	11.1	T
13.	Sec.	11.1	F
14.	Sec.	11.2	F
15.	Sec.	11.11	F
16.	Sec.	11.1	sagging, settlement, $^{1}/_{4}$ inch, span
17.	Sec.	11.1	joint, anchorages, 4 inches, lift
18.	Sec.	11.11	dirt, mortar, hardware, other material
19.	Sec.	11.3	shellac, lacquer, form oil
20.	Sec.	11.9	locking devices, joined together, stacked

Chapter 12—Proportioning the Concrete Mixture

1.	Table	12.1	c
2.	Sec.	12.6	b
3.	Sec.	12.0	a
4.	Sec.	12.9	a
5.	Sec.	12.1	e
6.	Sec.	12.2	d
7.	Sec.	12.0	e
8.	Table	12.1	c
9.	Sec.	12.1	b
10.	Sec.	12.5	F
11.	Sec.	12.7	T
12.	Sec.	12.8	T
13.	Sec.	12.5	F
14.	Sec.	12.2	F
15.	Sec.	12.1	T
16.	Sec.	12.3	F
17.	Sec.	12.1	F
18.	Sec.	12.3	MSA, job
19.	Sec.	12.2	inside, between
20.	Sec.	12.3	depth, three-quarters, forms, one-fifth
21.	Sec.	12.3	all, two, seven, 14, 28
22.	Sec.	12.5	water content, slump
23.	Sec.	12.1	Type II, 0.50, 5000

Chapter 13—Testing and Controlling the Concrete

1.	Sec.	13.1	e
2.	Sec.	13.4	e
3.	Sec.	13.2	e
4.	Sec.	13.5	b
5.	Sec.	13.4	b
6.	Sec.	13.8	d
7.	Sec.	13.1	e
8.	Sec.	13.5	a
9.	Sec.	13.4	b
10.	Sec.	13.10	c
11.	Sec.	13.6	e
12.	Sec.	13.6	c
13.	Sec.	13.5	e
14.	Sec.	13.9	T
15.	Sec.	13.2	F
16.	Sec.	13.10	T
17.	Sec.	13.4	T
18.	Sec.	13.10	F

19.	Sec.	13.4	T
20.	Sec.	13.6	F
21.	Sec.	13.6	T
22.	Sec.	13.5	T
23.	Sec.	13.4	T
24	Sec.	13.4	inches, low, high
25.	Sec.	13.2	observations, accuracy, reliability
26.	Sec.	13.1	voids, unit weight
27.	Sec.	13.4	slump, strength
28.	Sec.	13.3	verify, refute
29.	Sec.	13.2	representative

Chapter 14—Batching and Mixing the Concrete

1.	Sec.	14.1	b
2.	Sec.	14.3	b
3.	Sec.	14.9	c
4.	Sec.	14.3	b
5.	Sec.	14.9	c
6.	Sec.	14.7	d
7.	Sec.	14.8	d
8.	Sec.	14.1	a
9.	Sec.	14.6	e
10.	Sec.	14.9	b
11.	Sec.	14.1	F
12.	Sec.	14.1	T
13.	Sec.	14.10	T
14.	Sec.	14.1	T
15.	Sec.	14.8	T
16.	Sec.	14.9	F
17.	Table	14.1	F
18.	Sec.	14.5	T
19.	Sec.	14.9	batching, introducing, mixer drum
20.	Sec.	14.4	separately, cumulative, separate scales
21.	Sec.	14.2	scale, indicator, signal, designed weight
22.	Sec.	14.9	aggregates, water, ice
23.	Sec.	14.6	blades, one, other, paths
24.	Sec.	14.1	truck, wrong, mud, clay
25.	Sec.	14.9	truck, contractor, ready-mix batch plan, concrete,
26.	Sec.	14.4	clean, dull, dirty, fulcrums
27.	Sec.	14.5	central mixing, truck mixing, shrink mixing

Chapter 15—Handling and Placing the Concrete

1.	Sec.	15.3	a
2.	Sec.	15.2	b
3.	Sec.	15.2	a
4.	Sec.	15.1	c
5.	Sec.	15.5	b
6.	Sec.	15.3	a
7.	Sec.	15.4	e
8.	Sec.	15.3	e
9.	Sec.	15.2	d
10.	Sec.	15.2	d
11.	Table	15.3	e
12.	Table	15.3	e
13.	Sec.	15.5	T
14.	Sec.	15.3	F
15.	Sec.	15.3	T
16.	Sec.	15.2	T
17.	Sec.	15.1	T
18.	Sec.	15.2	F
19.	Sec.	15.1	F
20.	Sec.	15.4	T
21.	Sec.	15.5	T
22.	Sec.	15.3	T
23.	Sec.	15.1	F
24.	Sec.	15.2	T
25.	Table	15.3	T
26.	Table	15.3	F
27.	Table	15.3	F
28.	Sec.	15.1	regular, smooth
29.	Sec.	15.2	segregation, concrete, consistency
30.	Sec.	15.2	obstructions
31.	Sec.	15.3	high, mix, dry, sun, pumping
32.	Sec.	15.5	forms, reinforcing
33.	Sec.	15.1	anchor bolts, pipes, conduits, catch basins
34.	Sec.	15.3	P150, 100, 3000
35.	Sec.	15.5	spaced, consolidation, 5 to 15

Chapter 16—Slabs on Ground

1.	Sec.	16.3	a
2.	Sec.	16.3	c
3.	Sec.	16.1	e
4.	Table	16.1	d
5.	Sec.	16.2	c
6.	Sec.	16.1	a
7.	Sec.	16.1	b
8.	Sec.	16.2	b
9.	Sec.	16.1	d
10.	Sec.	16.2	b
11.	Sec.	16.2	T
12.	Sec.	16.1	F
13.	Sec.	16.1	F
14.	Sec.	16.3	F
15.	Sec.	16.2	F
16.	Sec.	16.1	F
17.	Sec.	16.2	T
18.	Sec.	16.2	T
19.	Sec.	16.2	F
20.	Sec.	16.2	F
21.	Sec.	16.4	subgrade, building
22.	Sec.	16.1	6
23.	Sec.	16.1	one day, damp
24.	Sec.	16.1	$^1/_8$, foot, $^1/_4$, foot, ponding
25.	Sec.	16.2	bulkhead, construction, predetermined
26.	Sec.	16.3	curing, slump, bleed water

Chapter 17—Finishing and Curing the Concrete

1.	Sec.	17.8	b
2.	Sec.	17.4	a
3.	Sec.	17.3	d
4.	Sec.	17.8	c
5.	Sec.	17.1	a
6.	Sec.	17.3	d
7.	Sec.	17.4	d
8.	Sec.	17.8	a
9.	Sec.	17.6	d
10.	Sec.	17.5	b
11.	Sec.	17.5	e
12.	Sec.	17.1	d
13.	Sec.	17.2	T
14.	Sec.	17.3	T
15.	Sec.	17.1	T
16.	Sec.	17.8	F
17.	Sec.	17.6	F
18.	Sec.	17.7	F
19.	Sec.	17.4	F
20.	Sec.	17.4	T
21.	Sec.	17.4	F
22.	Sec.	17.1	F
23.	Sec.	17.3	T
24.	Sec.	17.6	F
25.	Sec.	17.4	T
26.	Sec.	17.1	T
27.	Sec.	17.1	T
28.	Sec.	17.1	edging, chipping, damage
29.	Sec.	17.4	white, pigment, silica sand
30.	Sec.	17.1	high-carbon, 10, 20, 3, 5
31.	Sec.	17.8	burlap, cotton mats, fabric
32.	Sec.	17.3	abrasion, impact, after, disappeared
33.	Sec.	17.6	water, liquid membrane-forming, sheet materials, blankets
34.	Sec.	17.1	steel, bronze, malleable iron, 6, upturned
35.	Sec.	17.3	hard, tough, quartz, granite
36.	Sec.	17.5	spraying, nontoxic, damp, harmfully
37.	Sec.	17.8	strength, other properties, first few hours

Chapter 18—The Reinforcement

1.	Sec.	18.5	b
2.	Sec.	18.4	e
3.	Sec.	18.6	d
4.	Sec.	18.2	a
5.	Sec.	18.2	d
6.	Sec.	18.5	e
7.	Sec.	18.5	c
8.	Sec.	18.5	a
9.	Sec.	18.2	c
10.	Sec.	18.2	b
11.	Sec.	18.5	d
12.	Sec.	18.4	a
13.	Sec.	18.2	c
14.	Table	18.7	c
15.	Figure	18-4	c
16.	Figure	18-15	d
17.	Figure	18-15	a
18.	Figure	18-15	d
19.	Sec.	18.5	c
20.	Sec.	18.5	c
21.	Sec.	18.5	e
22.	Table	18.6	c
23.	Table	18.7	a
24.	Table	18.7	c
25.	Sec.	18.2	e
26.	Sec.	18.2	T
27.	Sec.	18.3	F
28.	Sec.	18.5	T
29.	Sec.	18.5	T
30.	Sec.	18.2	T
31.	Sec.	18.4	F
32.	Sec.	18.2	F
33.	Sec.	18.5	T
34.	Sec.	18.6	T
35.	Sec.	18.3	T
36.	Sec.	18.5	T
37.	Sec.	18.4	T
38.	Sec.	18.2	F
39.	Sec.	18.2	F
40.	Table	18.2	T
41.	Figure	18-4	F
42.	Sec.	18.2	T
43.	Sec.	18.4	T
44.	Sec.	18.9	T
45.	Sec.	18.2	F

46.	Sec.	18.2	T
47.	Sec.	18.2	one, 60, two, 75
48.	Sec.	18.5	beams, midspan, cover
49.	Sec.	18.6	freezing, thawing, de-icing salts
50.	Sec.	18.4	platforms, supports, damage, dirt, mud, rust
51.	Sec.	18.3	reinforcing, size, length, straight, bent
52.	Sec.	18.3	measurements, tolerances, one
53.	Sec.	18.5	chairs, ties, hangers, supports
54.	Sec.	18.4	building official, engineer, slowly, slowly
55.	Sec.	18.1	expansion, contraction, changes, cracking
56.	Sec.	18.2	designer, plans, bar lists

Chapter 19—Hot and Cold Weather Concreting

1.	Sec.	19.1	c
2.	Sec.	19.3	c
3.	Sec.	19.4	b
4.	Sec.	19.4	b
5.	Sec.	19.2	a
6.	Figure	19-3	b
7.	Sec.	19.3	e
8.	Sec.	19.2	e
9.	Sec.	19.1	F
10.	Sec.	19.4	F
11.	Sec.	19.2	T
12.	Sec.	19.1	T
13.	Sec.	19.2	F
14.	Figure	19-3	T
15.	Sec.	19.2	F
16.	Sec.	19.4	should not, mixing water
17.	Sec.	19.3	40 and 70, standard
18.	Sec.	19.2	uniformity, quality, overmixing
19.	Sec.	19.1	negative, reduced, aggressive
20.	Sec.	19.3	protection, hardened, little strength

Chapter 20—Precast and Prestressed Concrete

1.	Sec.	20.10	b
2.	Sec.	20.10	b
3.	Sec.	20.10	c
4.	Sec.	20.6	a
5.	Sec.	20.10	c
6.	Sec.	20.10	e
7.	Sec.	20.10	e
8.	Sec.	20.10	d
9.	Sec.	20.10	c
10.	Sec.	20.1	a
11.	Sec.	20.5	b
12.	Sec.	20.7	b
13.	Sec.	20.4	b
14.	Sec.	20.10	a
15.	Figure	20-29	d
16.	Sec.	20.5	c
17.	Sec.	20.6	T
18.	Sec.	20.0	T
19.	Sec.	20.6	F
20.	Sec.	20.6	T
21.	Sec.	20.1	F
22.	Sec.	20.6	F
23.	Sec.	20.10	T
24.	Sec.	20.4	T
25.	Sec.	20.6	F
26.	Sec.	20.7	F
27.	Sec.	20.3	F
28.	Sec.	20.6	T
29.	Sec.	20.6	F
30.	Sec.	20.10	T
31.	Sec.	20.3	T
32.	Sec.	20.6	F
33.	Sec.	20.6	T
34.	Figure	20-29	F
35.	Figure	20-29	T
36.	Sec.	20.4	T
37.	Table	20.1	high, low, smooth, shaped
38.	Sec.	20.10	before
39.	Sec.	20.2	fabricator, manufacturer
40.	Sec.	20.8	identical
41.	Sec.	20.6	anchors, tendons, ends
42.	Sec.	20.6	prior, concrete, after, concrete
43.	Sec.	20.6	stress relieved, loss, yield
44.	Sec.	20.7	embedded, made, anchorage, attachment
45.	Sec.	20.10	corrosion-preventive, lubricant, sheathing
46.	Sec.	20.6	28,000,000; eight

Chapter 21—Lightweight and Heavyweight Concrete

1.	Sec.	21.4	b
2.	Sec.	21.2	b
3.	Sec.	21.2	e
4.	Sec.	21.1	c
5.	Sec.	21.3	d
6.	Sec.	21.2	F
7.	Sec.	21.2	T
8.	Sec.	21.4	F
9.	Table	21.1	F
10.	Sec.	21.2	T
11.	Sec.	21.2	crushes, screens, small, coal, coke
12.	Sec.	21.3	air, gas, remaining
13.	Sec.	21.2	vibration, internal vibrators, segregation
14.	Sec.	21.2	absorbed, specific gravity, moisture
15.	Sec.	21.3	foaming agent, water, paddle, pan

Chapter 22—Special Concreting Techniques

1.	Sec.	22.1	d
2.	Sec.	22.2	a
3.	Sec.	22.7	d
4.	Sec.	22.13	b
5.	Sec.	22.13	b
6.	Sec.	22.4	a
7.	Sec.	22.14	c
8.	Sec.	22.8	e
9.	Sec.	22.1	a
10.	Sec.	22.5	d
11.	Sec.	22.13	b
12.	Sec.	22.2	e
13.	Sec.	22.8	c
14.	Sec.	22.13	a
15.	Sec.	22.7	d
16.	Sec.	22.13	c
17.	Sec.	22.10	c
18.	Sec.	22.13	b
19.	Sec.	22.1	e
20.	Sec.	22.13	b
21.	Sec.	22.15	c
22.	Sec.	22.16	d
23.	Sec.	22.16	c
24.	Sec.	22.17	a
25.	Sec.	22.16	d
26.	Sec.	22.18	d
27.	Sec.	22.19	e

28.	Sec.	22.19	e
29.	Sec.	22.3	F
30.	Sec.	22.7	T
31.	Sec.	22.13	F
32.	Sec.	22.11	F
33.	Sec.	22.7	F
34.	Sec.	22.12	F
35.	Sec.	22.13	T
36.	Sec.	22.6	T
37.	Sec.	22.13	F
38.	Sec.	22.13	T
39.	Sec.	22.2	T
40.	Sec.	22.13	F
41.	Sec.	22.2	T
42.	Sec.	22.4	T
43.	Sec.	22.1	F
44.	Sec.	22.15	F
45.	Sec.	22.15	F
46.	Sec.	22.16	T
47.	Sec.	22.15	F
48.	Sec.	22.17	F
49.	Sec.	22.15	F
50.	Sec.	22.16	T
51.	Sec.	22.18	F
52.	Sec.	22.18	T
53.	Sec.	22.18	T
54.	Sec.	22.11	T
55.	Sec.	22.16	T
56.	Sec.	22.16	T
57.	Sec.	22.7	mixing water, chamber, compressed air
58.	Sec.	22.11	gun, predetermined lengths, sand, cement
59.	Sec.	22.13	one, age
60.	Sec.	22.3	tremies, buckets, pumping
61.	Sec.	22.8	dry-pack mortar, grout
62.	Sec.	22.13	oxide, test panels
63.	Sec.	22.7	removed, sandblasted, doweled, bolted
64.	Sec.	22.13	hydrated cement, limestone, marble
65.	Sec.	22.10	three to four, freezing, thawing, sulfate, abrasion, decreased
66.	Sec.	22.4	slowly, previously placed

Chapter 23—Waterproofing and Dampproofing

1.	Sec.	23.2	b
2.	Sec.	23.3	a
3.	Sec.	23.5	c
4.	Sec.	23.1	c
5.	Sec.	23.4	d
6.	Sec.	23.4	F
7.	Sec.	23.3	F
8.	Sec.	23.2	T
9.	Sec.	23.3	T
10.	Sec.	23.3	T
11.	Sec.	23.3	clean, dry, smooth, filled, mortar, removed
12.	Sec.	23.5	unsound, encrustation, V-grooved, top, lowest
13.	Sec.	23.2	one, more, hot, cold, glass, plastic
14.	Sec.	23.3	grade, walls, floors, passage of liquid
15.	Sec.	23.1	well-graded, low porosity, rounded

Chapter 24—Introduction to Inspection

1.	Sec.	24.1	c
2.	Sec.	24.1	a
3.	Sec.	24.8	e
4.	Sec.	24.4	d
5.	Sec.	24.12	a
6.	Sec.	24.10	c
7.	Sec.	24.11	e
8.	Sec.	24.6	b
9.	Sec.	24.1	T
10.	Sec.	24.9	T
11.	Sec.	24.1	F
12.	Sec.	24.5	T
13.	Sec.	24.12	T
14.	Sec.	24.7	F
15.	Sec.	24.7	T
16.	Sec.	24.12	F
17.	Sec.	24.7	F
18.	Sec.	24.6	F
19.	Sec.	24.10	dry, oven, hot plate
20.	Sec.	24.9	quality control, specifications, properties
21.	Sec.	24.7	service, mill, factory, tests, independent
22.	Sec.	24.5	job, construction documents
23.	Sec.	24.1	suggestions, instructions, workers
24.	Sec.	24.10	trash, mud, contaminates

Chapter 25—Inspection of Concrete Construction

1.	Sec.	25.3	c
2.	Sec.	25.9	b
3.	Sec.	25.10	a
4.	Sec.	25.8	b
5.	Sec.	25.2	c
6.	Sec.	25.9	d
7.	Sec.	25.1	b
8.	Sec.	25.5	d
9.	Sec.	25.4	F
10.	Sec.	25.6	T
11.	Sec.	25.0	F
12.	Sec.	25.1	T
13.	Sec.	25.8	F
14.	Sec.	25.10	T
15.	Sec.	25.5	T
16.	Sec.	25.2	T
17.	Sec.	25.6	F
18.	Sec.	25.9	T
19.	Sec.	25.10	F
20.	Sec.	25.10	F
21.	Sec.	25.1	batching, mixing, placing, finishing
22.	Sec.	25.7	permit, size
23.	Sec.	25.9	inspection reports, design drawings, specifications
24.	Sec.	25.9	amendments, procedures, requirements
25.	Table	25.1	calibration, sequence
26.	Sec.	25.4	tamping, rolling, aggregate
27.	Sec.	25.2	load ticket, thoroughly mixed, time limits

Chapter 26—Quality Control

1.	Sec.	26.1	b
2.	Sec.	26.2	d
3.	Sec.	26.2	a
4.	Table	26.1	a
5.	Sec.	26.1	c
		26.1	
6.	Sec.	26.3	a
7.	Sec.	26.3	c
8.	Sec.	26.1	T
9.	Sec.	26.1	T
10.	Sec.	26.1	T
11.	Sec.	26.1	F
12.	Sec.	26.2	F
13.	Sec.	26.1	concrete strength, analysis, sand, continuing
14.	Sec.	26.2	quality, strength, results
15.	Sec.	26.2	percentage, lower, design
16.	Sec.	26.1	does not, savings
17.	Sec.	26.2	uniformity, quality, materials, manufacture, controlled